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(4) POWER-LINE COMMUNICATION APPARATUS.

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US-A- 4 885 563 PATENT ABSTRACTS OF JAPAN vol. 10, no. 283 (E-440)(2339) 26 September 1986

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EP 0 470 185 B1

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De cription

Related Application

This application is a continuation-in-part of U.S. Serial No. 429,208 filed October 30, 1989 which is itself a continuation-in-part of U.S. Serial No. 344,907, filed April 28, 1989.

Background of the invention

1. Field of the Invention

The present invention is related generally to power system communications, and more particularly to apparatus capable of simultaneously transmitting and receiving digital data signals both at high rates and over long distances through power-lines and through power line transformers, including AC, DC and coaxial cables (including phone lines).

2. Statement of the Prior Art

"Power-line carriers" are well known in the field of power system communications. The principal elements of such power-line carriers are transmitting and receiving terminals, which include one or more fine traps, one or more coupling capacitors, as well as funing and coupling equipment. Detailed information tegarding the description and typical composition of conventional power-line carriers may be found in Funconventional power-line carriers may be found in Funcional power-line carriers and Systems, John Wiley & Sons, 1983, pp. 617-627. TK151.F86, the contents of which are incorporated herein by reference.

A power line communication system is generally known from EP-A-0 115 814 A1. This system is characterized by a signal transmitter cooperating with a three-phase power line by means of a circuit including a transformer unit and capacitors functioning as a coupler means.

A significant problem associated with such prior art power-line carriers is their requirement for one or more line traps, one or more coupling capacitors, one or more caurier or one or more carrier frequency hybrid circuits and frequency connection cable. Furthermore, in traditional systems the modulation at the transmitter and receivers is not synchronized. Traditional systems experience distance limitations whenever AM or FM demodulation is used, and the power-linees. To the extent that the carrier from quency is received at all, it is often too weak to dequency is received at all, it is often too weak to dequency is received at all, and expense and the pand-during and expense at the modulate. Such systems further have a narrow band-midth and expenience no less than a 20dB loss at the width and experience no less than a 20dB loss at the

carrier frequency.

One prior art method operates at a frequency of

betwe n betwe n 20KHz and 400Khz where th att nustion of the power lin is greater. How ver, the 60Hz harmonics are still picked up by such a system. Accordingly, th re is still a n ed to use high power transmission b caus of noise and coupling losses of greater than 20dB. As a result, the signals must be transmitted over the power-lines at very high power

Still other prior art methods operate below 20 KHz where the attenuation of the power-lines is lower. However, such systems experience a high level of noise and a very small bandwidth. These systems also experience at least a 20dB loss through the coulso experience at least a 20dB loss through the cou-

outputs and low bandwidths.

All existing systems attempt to communicate between the harmonics rather than by reducing the noise significantly through the coupler. In addition, prior art systems are location with respect to transfected by their relative position with respect to transformers or other plugged in equipment. Frequently, prior art power line communication mechanisms must perform a frequency transponent in both the transmitter and receiver, thus requiring two or more quartz oscillators.

Finally, all previous power line communication of systems are characterized by their incorporation of magnetic or ferrite (iron) core linear transformers for both transmission and reception in the duplexing system. Because these systems are magnetically coutem. Because these systems are magnetically coupled and the 60Hz current is greater than zero, they pass a significant amount of the 60Hz high power signates as a significant amount of the 60Hz high power significant amount of the 60Hz

pass a signmeant amount of the corraining power signals and its resulting harmonmics.

The use of magnetic transformers for transmission is itself a cause of several problems. First, magnetic transformers are affected by distribution transformers and devices incorporating magnetically coupled transformers. Magnetic transformers tend to pled transformers. Magnetic transformers tend to pass back large percentages of the 60Hz power-line currents which can damage the transmitter. The concurrents which can damage the transmitter. The concurrents which can damage the transmitter problem has been to increase the ratio of the primary to secondary windings to 10:1. While this results in a smaller "back" current passed to the transmitter, it consequently recurrent passed to the transmitter, it consequently requires high power transmission of the carrier signal.

a 20 (decebel) dB power loss over their associated coupling capacitor.

The problems associated with the use of magnetic franaformers in receivers are equally significant. The use of magnetic linear transforms require the use of magnetic linear transforms require the use prior art systems are slow (maximum of 100 baud). The transformer further picks up the magnetic field for every frequency and accordingly picks up the 60Hz signal and its harmonics. This further exacer-

systems. Thus, such systems frequently experience

resonate with the coupling capacitors used with such

Further, systems using magnetic transformers do not

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equally applicable to any high voltage DC communiair coil transformers of the present invention are through any power line transformer. Finally, the novel with about a 6 KHz bandwidth for communication tion at frequencies up to 35 KHz (preferably 7-15KHz) voltage and LAN communications; and communicawith about a 20 KHZ bandwidth for high distance, high tions; communication at frequencies up to 160 KHz (local area networks) and phone line communicaa 200 KHZ bandwidth) for applications including LAM tion at frequencies up to 1 MHz (with less than about p mit high sp ed, high band power lin communica-

paratus which utilizes novel non-linear transformera invention to provide a power line communications ap-In view of the above, it is an object of the present cations preferably up to 160 KHz.

provide power line communication apparatus utilizing It is a further object of the present invention to for both transmission and reception.

It is an additional object of the present invention communication through power line transformers. phone line, coaxial, LAN, power line and power line novel air coil transformers which can be used for

trequency. onation effectively creates a band pass filter at carrier tages at the respective carrier frequencies. This resder to maximize the transmission and reception volwith an associated coupling capacitor network in orwhich the primary coil of the transformer resonates to provide a power line communication apparatus in

.f:f tuods si secondary windings in which the ratio of the windings non-linear transmission transformer has primary and to provide a communications apparatus in which a It is still a further object of the present invention

harmonica. which impedes the 60Hz high power signal and its the receiver coupling contains a capacitor network tion to provide a communications apparatus in which It is still yet a further object of the present inven-

.f:f Juods is about 1:1. transformer in which the ratio of the primary to secthe receiving network includes a non-linear air coil tion to provide a communications apparatus in which It is still yet a further object of the present inven-

system against spiking and lightning. voltage evenly. The resistors also serve to protect the Ception include resistors which divide down the AC the capacitor network for both transmission and retion to provide a communications apparatus in which It is still yet a further object of the present inven-

baud, and at speeds of up to 1200 baud directly communications signals at speeds greater than 9600 can provide a high bandwidth for the transmission of tion to provide a communications apparatus which It is still yet a further object of the present inven-

It is yet a further object of the present invention through power line transformers.

> transformers. which can be further aggravated by other power line ditions t the power line. This can result in mistuning transformer which will not allow good matching conformer will be effected by the s condary sid of the th impedanc of the primary of th magnetic trans-

> SIOU. which require at least 600 watts of power for transmisalso typically loud and require expensive repeaters Prior art power line communications aystems are

> match the impedance of the phone line well. problems. The impedances of such systems do not which have similar narrow bandwidths and noise tion also use magnetically coupled transformers Prior art methods of telephone line communica-

> attenuate the low frequency power signal and its harproduce a narrow bandwidth and do not adequately can particularly be seen in Figure 3, such systems sa applied in power line communications systems. As associated with prior art magnetic linear transformers Figures 1-3 schematically illustrate the problems

> power line. from a systematic standpoint, function as part of the perience gain for reception and transmission, and non-linear transformers of the present invention extransformers characteristic of prior art systems, the low power transmission. In contrast to magnetic power line transformers over long distances and at ent invention permit communication directly through frequencies. The novel air coil transformers the pressignal for better transmission and reception of carrier which thereby simultaneously maximize the carrier mize the 60Hz power signal and its harmonics, and ebective resonating capacitor networks which miniitively coupled air coil transformers coupled with re-The present invention incorporates non-linear capacis directed to solving the above-mentioned problems. The present invention, characterized by Figure 4,

> communications over great distances. spove factors work to produce high speed power line cause attenuation is equal in both directions. All of the mers are irrelevant using this coupling technique, bestep-up or step-down aspects of power-line transforwhich will be a function of part of the power line. The the resistivity of the primary air coil to the power line, quently, impedance matching can be achieved using effect from other power line transformers. Consethe secondary side-of the air coil and no impedance coil transformers creates no impedance effect from jority of the harmonics are eliminated. The use of air transformer passes none of the 60Hz signal, the ma-60Hz power line signal and because the nonlinear system noise is generated by the harmonics of the frequencies for which they are designed. Because tion are capacitively coupled and will only pick up the The non-linear transformers of the present inven-

The air coil transformers of the present invention

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lines, coaxial lines and any high voltage DC power plications include data transmission through phone printers at sp eds in xcess of 9600 baud. Other apb n used to transmit data between computers and min s. The apparatus of the present invention has

drawings wherein: considered in conjunction with the accompanying from the following detailed description thereof, when the present invention will become more apparent Other objects, advantages, and novel features of

Brief Description of the Drawings

duplexing couplers on both low and high voltage pow-Figs. 1 and 2 schematically represent traditional

Fig. 4 schematically represents the LC coupler of traditional serial LC couplers. Fig. 3 illustrates the frequency characteristics of

the present invention.

Fig. 6 is a block diagram of a power-line commuthe LC coupler of the present invention. Fig. 5 illustrates the frequency characteristics of

vention; nication apparatus in accordance with the present in-

uication apparatus in accordance with the present in-Fig. 6A is a block diagram of a power-line commu-

which corresponds to the coupling TA-RB shown in means in accordance with the present invention, Fig. 7 is a schematic diagram of first coupling vention including power-line transformers;

means in accordance with the present invention, Fig. 8 is a schematic diagram of second coupling Figs. 6 and 6A;

Figs. 6 and 6A; which corresponds to the coupling TB-RA shown in

mer air coils utilized in the present invention. Figs. 9A and 9B illustrate the non-linear transfor-

cordance with the present invention for data commu-Fig. 9C illustrates a half duplexing coupler in ac-

modulator FA/demodulator FB for the system in Fig. Fig. 10B is a schematic diagram of an alternative the modulator FA/demodulator FB shown in Figure 6. Fig. 10A is a schematic diagram corresponding to nications through distribution transformers.

Fig. 10C is an FSK decoder phase lock loop

cuit of Fig. 6; which can function as the modulator/demodulator cir-

Fig. 10D is the primary phase lock loop of Fig.

Fig. 11 is a schematic diagram of a transmitter

data signals over long distances. shown in Fig. 11, in the power-line communication of used in conjunction with the transmitter means Fig. 12 is a schematic diagram of receiver means means used in the present invention;

> tion to provide apparatus for power system commu-It is still yet a further object of the present invensmall coupling capacitance between the solenoids. diam t re thus defining an air gap, which creates a two single layer finite sol noids each having different non-linear air coil transformer effectiv ly comprising to provide a communications apparatus containing a

> It is still yet an additional object of the present apnications over long distances.

> ear transformer have different diameters. which the primary and secondary coils of the non-linparatus to provide power line communications in

> mary side of the non-linear transformer. in which coupling capacitor resonates with the priprovide an apparatus for power line communications It is yet another object of the present invention to

> communications. bied with a capacitor hetwork for use in telephone line to provide a novel non-linear air coil transformer cou-It is still a further object of the present invention

Summary of the Invention

cording to daim 1. ratus for power-line communications is disclosed ac-In accordance with the present invention, appa-

pass filter. ings, with the coupling capacitance, function as a high capacitance through the air gap, the secondary wind-(which function as solenoids) create a small coupling least 80dB attenuation. Because the sir windings which cut the 60Hz harmonics below 10KHz with at works) as the non-linear transformer (high pass filter) air windings function (with resonating capacitor netinvention, air coils comprising primary and secondary In accordance with a major aspect of the present

through the phone sytem. tage power-lines using addressable data transmitted curity systems in homes could be set up over high voldition, public phone systems in trains and internal se-(13,800, 22,000, 69,000 voltage power-lines). In adand directly through the distribution transformer house (120/240/480 Volts), to the distribution line, with addressable data using two frequencies from system, such readings could be made by a computer through power line transformers. In a hypothetical high data rates, over long distances and directly Such readings can be transmitted at low power, at over power-lines for large numbers of customers. sible to transmit electricity and gas meter readings way of example, the present invention makes it posnications between computers over power-lines. By switching of remote control devices, and data commucations are in electricity and gas meter readings, the vention has numerous applications. The main appli-The communications apparatus of the present in-

control large or small machines in factories and The present invention can be further utilized to

d modulator m ans 28. Th combination of transmitt r means 24, receiver means 26 and modulator/demodulator m ans 28 comprise a second modem means 23.

to function as a simple receiver or transmitter. nications apparatus, either circuit may be configured ing described in the context of two identical commu-It is to be noted that while the present invention is beinductive (L) component of the respective LC circuits. both transmission and reception which serve as the corporates novel non-linear aircoil transformers for See Figure 4. The coupling means 14, 22 further inare connected in a series and parallel configuration. The LC circuits include a plurality of capacitors which pling means 14, 22 resonate at a given frequency. of the serial LC circuits in a respective one of the couratus is coupled to power-line transformers 27. Each pair of power-lines 12. Referring to Fig. 6A, the appaisl LC circuits (Figs. 7 and 8) which are coupled to the low, both coupling means 14, 22 include a pair of serxplained in gr ater detail herein bed liw sA

The first transmitter means 16, coupled to the first coupling means 14, is capable of transmitting digital data signals carded by a first carrier frequency FA across the pair of power-lines 12, and as shown in Fig. 6A, through power line transformers. The first receiver means 18, coupled to the first coupling means 14, is capable of receiving digital data signals carried by a second carrier frequency FB from the pair of power-lines 12. The modulator/demodulator means 16, coupled between the first transmitter means 16 and the first receiver means 18, modulates the digital data signals to be carried by the first carrier frequency FA, and demodulates the digital data signals to be carrier frequency FA, and demodulates the digital carrier frequency FA, and demodulates the digital data signals carried by the second carrier frequency FB.

the first camer frequency FA. and demodulates the digital data signals carried by nals to be carried by the second carrier frequency FB ond receiver means 26, modulates the digital data sigtween the second transmitter means 24 and the sec-The second modulator/demodulator 28, coupled becarrier frequency FA from the pair of power-lines 12. receiving the digital data signals carried by the first to said second coupling means 22, and is capable of Accordingly, the second receiver means 26 is coupled as shown in Fig. 6A, through power-line transformers. frequency FB across the pair of power-lines 12, and digital data signals to be carried by the second carrier transmitter means 24 is capable of transmitting the is coupled to the second coupling means 22. Second the power-lines 12, the second transmitter means 24 In a similar manner, at the second location along

The first and second carrier frequencies FA, FB preferably comprise frequencies up to 1MHz (megahertz), at a power level of about 20 decibels above any other frequencies. The bandwidth of each of the coupling means 14, 22 preferably comprises less than 30 kilohertz. For most high voltage, long distance

Fig. 12A is a sch matic diagram of a reciv rwhich can be us d for high spe d communications.

Fig. 13 is a sch matic representation of a cou-

pling for the power line from phase to ground.
Fig. 14 is a sch matic representation of a thre
phase coupling to the powerline, three phases to

ground.
Fig. 15 illustrates a two phase coupling connection to the power line phase to these

tion-to the power line, phase to phase.

Fig. 16 shown a three phase transformer cou-

pling of the type predominantly used in Europe. Fig. 17 shows a one phase transformer coupling

of the type generally used in the United States, Fig. 18 shows a spread spectrum transmitterire-ceiver in accordance with the present invention which is particularly applicable for communication in be-

tween noise.
Fig. 19 B-Polar Shift Keying transmitter/receiver
which can be utilized with the present invention

which can be utilized with the present invention.

Fig. 20 is an equivalent circuit of the upper and underground power line with the power line impendently of the power line in the power

dances.
Fig. 21 is a graph of power line attenuation versus carrier frequency on the 35 K/A/C power line for a 20

KM distance.
Fig. 22 is an illustration of an electric meter reading system incorporating the communication system of the present invention which may be implement by a utility.

Fig. 22A is a block diagram illustrating the use of the couplers of the present invention within a LAN linked by power lines or conventional phone lines.

Fig. 23 is a block diagram of the system of Figure 22 as applied to a multiplicity of substations.

Fig. 24 is a simplified block diagram of the system of Fig. 22. Fig. 25 is a block diagram of a power line commu-

Detailed Description of the Invention

nication system.

Referring now to the Figures, wherein like numbers designate like or corresponding parts throughout each of the several views, there is shown in Figs. 6 and 6A block diagrams of a power-line communication apparatus 10 according to the present invention for use in low power applications (up to 480 VAC).

The communications apparatus 10 shown is coupled to a pair of power-lines 12, and generally comprises first coupling means 14, first transmitter means 16, first receiver means 18, and first modulator means 20 at a first location along the power-lines 12. The combination of transmitter means 16, receiver means 18 and modulator/demodulator means 20 comprise a first modem means 21, as econd location along power-line 12 are second coupling means 22, second transmitter means 24, second transmitter means 24, second receiver means 26, and second modulator-second receiver means 26, and second modulator-

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together in parall I between one of th power-lines 12 and th primary winding 38 of the first air coil 36. The phrmary winding 38 of the first air coil 36 is thereafter serially connected to th other power-line 12. The secondary winding 40 of the first air coil 36 is connected to its respective transmitter means 16. The second plurality of capacitors 42 are serially connected to its respective transmitter means 15. The primary winding 46 of the second air coil 44. The primary winding 46 of the second air coil 44. The primary winding 46 of the second air coil 44 thereafter being serially connected to the other power-line 12. As noted above resistors, 35 and 45 function to evenly divide the voltage and serve to minimize spiking by divide the voltage and serve to minimize spiking by divide the voltage and serve to minimize spiking

current at the carrier frequency FA. filter at the carrier frequency FA. This maximizes the at the carrier frequency FA, thus creating a band pass ther Cent is set to resonate with the primary winding thereby achieving a gain on the secondary side. Furart devices. The primary coil resonates with Ceqt, high transmission voltage, as is characterized by prior ratio. Accordingly, the transmitter doesn't require a turns (designated by $N_1 = N_2$), and are thus at a 1:1 in the transmitter air coils have the same numbers of that both the primary and secondary windings 38, 40 tween the two. Of particular significance is the fact winding 2r 41 and accordingly creates an air gap bewhich is greater than the diameter of the secondary The primary winding 38 has a winding diameter 2R 39 ing 40 which is placed between the primary winding. mary winding 38 and coaxial smaller secondary wind-The transformer is non-linear and comprises a priconnected in series with Coq1 and the power line 12. shown in Fig. 9A, the transmitter transformer 36 is former 36 with coupling capacitor network Cedi. As reception. Figure 9A illustrates the transmitter transpled air coil transformers for both transmission and function as respective non-linear capacitively coubed in greater detail. The novel air coil structures transformers used in the present invention are descri-Referring to Figs. 9A-9C, the non-linear air coil and afford lightning protection.

The values of C_{eq1} and the resistors 35, 45 are set to generate a large voltage loss at frequencies less that 10KHz (thus encompassing the 60Hz power line signal). Thus, the significantly reduced 60Hz signal cannot generate a large enough current to pass the created small capacitance. That is, for transmission, the resistivity of the primary coil is roughly equal to the input impedance of the power line.

The receiver transformer is now described with respect to Fig. 9B. The receiver is connected to the power line 12 vis C_{ed2}. As with the transmitter of Figure 9A, the receiver sir coil comprises a non-linear transformer having a primary winding 46 with a first baving a second dismeter 2r 49. Accordingly, an sir paving a second dismeter 2r 49. Accordingly, an sir paving a second dismeter 2r 49. Accordingly, an sir paving a second dismeter primary and secondary cre-

communications, the first and second carrier frequencies FA, FB will typically compris frequenci s that are less than about 160 KHz, having bandwidths of less than 20 KHz. When used for communication through power line transformers, FA and FB will typically comprise frequencies below 35 KHz (preferably 7-15 KHz) with bandwidths of about 6 KHz. The serial LC circuits (Figs. 7 and 8) of both coupling means 14, 22 each comprise impedance matching means 14, will be described in greater detail below.

With reference next to Figs. 7 and 8, the specific circuitry for representative coupling means 14, 22 is now described in greater detail. The coupling means of (Fig. 8) each include a pair of serial LC circuits 30, 32 which resonate at the carrier frequency cies FA, FB. It will be appreciated by those skilled in the art that for FSK (Frequency Shift Key) applications FA will correspond to F, and F₂ and FB will correspond to F, and F₂ and FB will correspond to F, and F₂ and FB will correspond to F6. The serial LC circuit 30 shown in Fig. 7 resonates at the second carrier frequency FA. Similarly, the serial LC circuit 30 of rier frequency FA, similarly, the serial LC circuit 30 of serial LC circuit 32 resonates at the first carrier frequency FA. Similarly, the serial LC circuit 30 of serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier serial LC circuit 32 resonates at the second carrier second carrier the serial LC circuit 32 resonates at the second carrier second carrier the serial LC circuit 32 resonates at the second carrier tequency FB.

DC current so as to prevent spiking and afford light-The use of the resistors 35, 45 serve to minimize the lator and the air coil transformer placed into a resin. itors should be separately placed in an oil filled insu-22 KV. At operating voltages above 22 KV, the capacsulation when used with operating voltages up to to plers (LC) should be placed into a resin for good initors should similarly be high. In operation, the couthick film (i.e. carbonless). The Q point of the capac-VAC capacitors. The resistors should preferably be oum per 5 watts and the capacitors should be 200 ably, the resistor values should be rated at 1 Megawhich evenly divides down the AC voltage. Prefereach capacitor in series is connected a resistor 35, 45 parallely connected capacitor networks 34, 42. To The LC circuits include respective serially and

It is to be appreciated that the capacitor networks 34, 42 create equivalent capacitances $C_{(eq1)}$ and $C_{(eq2)}$ for transmission and reception, respectively. The capacitor networks are connected to non-linear air coil transformers to be discussed below which function as the inductive element (L) of the LC circuit. $C_{(eq1)}$ and $C_{(eq2)}$ resonate with the primary windings of the non-linear transformers.

ning protection.

The sir coil means comprise a first sir coil 36 which includes a primary winding 38 and a smaller secondary, winding 40 situated coaxially within the primary winding. The second sental LC circuit 32 includes second sir coil 44 including a primary winding 46 and smaller secondary winding 48 situated coaxially within the primary winding.

The first plurslity of capacitors 34 are connected

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The theoretical op ration of th circuit is seen with r f rence to Fig. 20, an equivalent circuit of the upper and underground power lin , which also shows the LRC values required to match the coupler to the power lin . At primary resonation, th LC impedance as will be zero at transmission and reception such that the resistivity of the primary coil RT matches the input impedance of the power-line. On the receiver side, RR, has to be larger than the input impedance of the power-line. On the receiver of the power line. These relationships facilitate long distance communication.

The coupling means 14, 22 shown in Figs. 6, 7, 8, 9A and 9B are suitable for communication in association with wide range of power-line voltages. As will be discussed herein, they can be utilized for high voltage, low voltage, LAN and phone line communications, as well as for communication directly through power line transformers.

A. Communication Options

1. Computer communication through Power and Phone Lines

utilizes the moderns shown in Figures 10t, 11 and about 1.6 cm, #30 magnet gauge wire. The system and a secondary winding 48 with a coil diameter of mary winding 46 of 2.2 cm, #34 gauge magnet wire magnet wire. The second air coil 44 should have a pri-40 with a coil diameter of about 1.6 cm, #34 gauge of 2.2cm, #26 gauge magnet wire secondary winding should have a primary winding 38 with a coil diameter pacitance of 100 nanofarads. The first air coil 36 capacitor having a 1.6KV working voltage and a capluralities of capacitors 34, 42 as shown therein, each 1KVAC. The coupler preferably uses first and second 117.5 KHz for FSK) over power-lines 12 of up to about ond carrier frequency FB of around 111 KHz (and of around 75 KHz (and 81.5 KHz for FSK) and a secmeans 14 preferably use a first carrier frequency FA to 10 Kilobaud. For this application, the coupling munications and facilitate communication speeds up plied to LAN (local area network) and phone line com-The couplers of the present invention can be ap-

On the other side of the system, coupling means 22 comprises first and second pluralities of capacitors 34, 42 as shown therein, each capacitor having a 1.6kV working voltage and a capacitance of 100 menotareas, along with the non-linear air coil transformer. As above, the first air coil 36 should have a primary winding 38 with a coil diameter of 2.2 cm, #36 gauge magnet wire and a secondary winding 40 with a coil diameter of 1.6 cm, #34 gauge magnet wire. The second air coil 44 should similarly have a primary winding 46 of about 2.2 cm, #34 gauge magnet wire and a secondary winding 48 with a coil diameter of about 2.5 cm, #34 gauge magnet wire.

windings 46, 48. In th receiver transformer, the ratio of the primary and secondary windings must b greater than or equal to 1:1, at carrier frequencies below 1:1 at carrier fr quencies and may b below 1:1 at carrier fr quencies great r than 1MHz. While this ratio can b altered or modified, such a change requires a resultant alteration in the size of the sir gap, i.e. the relative ratio of SR and 2r. The capacitor network C_(eqz) is set to resonate with the primary winding at carrier frequency onate with the primary winding at carrier frequency.

In operation, the power line voltage is significantly reduced by C_{eq2} and the resistors. Thus, the created capacitance with the secondary winding significantly attenuates the harmonics and 60Hz signal to about zero, thus effectively functioning as a high pass filter. The carrier frequency voltage is thereby maximized. The sir coil produces a signal having a wider bandwidth than previous systems. The bandwidth characteristics of the present invention are shown in Figure 5. For reception, the resistivity of the primary should be greater than the impedance of the power line.

From a design standpoint, then, the philosophy is to minimize the 60Hz line voltage and its harmonics. The circuit can be thought of as a series CRL circuit on the transmission side where: for the primary;

 $V_{PRIMARY(80Hz)} = V_{power-line}(ZI)/(Zc)$ and for the secondary;

f²(carrier)/f²(60Hz), determines the V_{carrier}/V60Hz frequency characteristic ratio which will always be sround 100dB or greater. Preferably, a higher carrier traquency should be used for higher power line voltages. On the receiver side, the ratio of the impedance of inductance to capacitance, i.e. ZL/ZC must be minimized. Thus, ZC should be maximized at 60Hz. Consequently, because l_{80Hz} = VPL/ZC, ZC should be maximized at 60Hz.

this coupling technique, because attenuation is equal pects of power-line transformers are irrelevant using of part of the power line. The step-up or step-down asmary air coil to the power line, which will be a function ing can be achieved using the resistivity of the priline transformers. Consequently, impedance matchthe air coil and no impedance effect from other power ates no impedance effect from the secondary side of are eliminated. The use of air coil transformers crenone of the 60Hz signal, the majority of the harmonics signal and bec<mark>ause the nonlinear transformer passes</mark> is generated by the harmonics of the 60Hz power line is concentrated below 10KHz. Because system noise in the art that the noise component of the 60Hz signal transformers, it is to be appreciated by those skilled siple to communicate directly through power line its harmonics below 10KHz. The above makes it posgap) serve to completely filter the 60Hz current and earlity of the transformers (i.e. the existence of the air The above relationships coupled with the non-lin-

in both directions.

Transformers 3. Communication Through Power Lin

couples will cover the F₁ and F₂ frequencies. tors (up to 22 KV power-line), the bandwidth of the (4.5KVAC) capacitors with 6 Megachm/5 Watts resis-12.9 KHz, using five serial and 100 nanofarad Spectrum using half-duplex with F₁ = 12.1 KHz F₂ = through the transformer in FSK, BPSK or Spread baud. It is to be appreciated that for communication transformers at communication speeds of up to 1200 22). The couplers permit communication through nication through power-line transformers (See Figure th pres nt inv ntion may also be utilized for commu-As not a show, the communication apparatus of

below 10KHz is reduced significantly, and the carrier receiver coil is uncoupled. In this configuration, noise must be uncoupled. In order to have transmission, the the receiver coil 58. For reception, the transmitter coil middle is the transmitter coil 56 and the narrowest is is the primary which resonates with the capacitor, the gauge magnet wire. The largest diameter outer coil 54 gauge magnet wire and the smallest 58 is 8.0 cm, #30 gauge magnet wires, the middle 56 is 8.9 cm, #26 ized. The diameter of outer coil 54 is 11.4 cm, #26 (aircoils) having three different diameters are utiltribution transformers. In this system three solenoids communication through the high voltage side of dis-Fig. 9C illustrates a half-duplex coupler for data

ary coil 40 having a diameter of 3.8 cm using #34 4.0 cm using #26 gauge magnet wire with the secondthis situation, the primary coil 38 has a diameter of pled to two 250 nanofarad capacitors (500 VAC). In secondary). (See Figure 22). The transformer is couthe low voltage side (i.e. a single primary and single use the same carrier frequency, with one coupler on 480 V power lines, the system can be configured to tion transformer corresponding to the 120, 240 and On the low power side of the power line distributrequency through the couplers has a gain.

signed to be simultaneously transmitted. present invention will permit more than one carrier It is to be appreciated that the couplers of the gauge magnet wire.

8. Transmitter and Receiver Devices

tively slow, is more powerful for long distance (i.e., 10 transistors 66, 68, the transmitter 16 while compara-TFA/B2. Because of its use of a magnetic coil 64 and 14, 22 by way of their respective connections TFAB1, a driver 62 which is connected to the coupling means formers. The transmitter means generally comprises tion, including transmission through power line transutilized in all of the applications of the present invendistances is shown in Fig. 11. This transmitter can be power-line communication of data signals over long The preferred transmitter 16, 24 useful in the

2. High Voltage Pow r Lin Communications

large high voltage transmission lines. typically be located at a ground station adjacent to having a height of approximately fifteen feet and will that the above system will be comparatively large, MegaOhm per 5 watt resistors. It is to be appreciated nanofarad capacitors connected in series, with 5 suitably comprises one branch of three hundred 100 and connected in series, while the second plurality 42 branches of three hundred 100 nanofarad capacitors 8. The first plurality 34 suitably comprises two parallel somewhat modified over what is shown in Figs. 7 and first 34 and second 42 pluralities of capacitors are respectively, are preferred, and the connections of ond FB carrier frequencies of 80 KHz and 120 KHz, up to 9600 baud. In this application first FA and secinvention can be utilized for communication speeds voltages of up to 750KV. The couplers of the present KVDC/4.5KVAC capacitor can b used for power-line power line communication applications in which a 15 Th coupl is are als applicable to high voltage

lated according to the equation $L = 1/4 \text{ s} \cdot C_{eq}$. magnet wire. The inductivity of the primary is calcuwinding 48 with a coil diameter of 6.0 cm, #26 gauge 10 cm, #20 gauge magnet wire, and a secondary likewise suitably comprises a primary winding 46 of cm of #26 gauge magnet wire. The second air coil 44 part secondary winding 40 with a coil diameter of 6.0 dismeter of 10 cm, #20 gauge magnet wire, and a two-14 suitably comprises a primary winding 38 with a coil application, the first sir coil 36 of the coupling means Referring to the non-linear transformers for this

eter of about 6.0 cm, #26 gauge magnet wire. net wire and a secondary winding 48 with a coil diames a primary winding 46 of 10.0 cm, #20 gauge magwire. The second air coil 44 likewise suitably compriswith a coil diameter of 6.0 cm, #26 gauge magnet #20 gauge magnet wire and a secondary winding 40 es a primary winding 38 with a coil diameter of 10 cm, itors connected in series. The first sir coil 36 compristwo branches of three hundred 100 nanofarad capacies, while the second plurality 42 suitably comprises hundred 100 nanofarad capacitors connected in serplurality 34 suitably comprises one branch of three plurality 34, 42 being connected in parallel. The first islly connected capacitors, all of the branches of each 34, 42 comprising a number of branches of 300 sercircumstances also includes the capacitor pluralities The identical coupling means 22 under the same

cially above 100 KHz. the attenuation of the power line will increase espenumber of transformers in the power line increase, tion can be seen here from 70 to 160 KHZ. As the matching conditions. The best range of communicafor 20 KM distances. A 150 ohm load was used for the versus carrier frequencies on the 35 KVAC power line Figure 21 is a graph of power-line attenuation

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it frequencies (FA and FB). The values of C1, R3 and R4 are varied to alter the FA and FB carrier trequencial

Figure 10B illustrates an alternative FM modulator and d modulator 20' for high frequency communication. The cation for LAN and phone line communication. The circuit incorporates the XR-210 FSK demodulator computer input/output interface. The values for R₀, C₀, C₁, C₂, C₃, and C₄ are utilized to after the carrier frequencies (FA and FB). The values of C₁, R₃ and R₄ are values of C₁, R₂, R₃ and R₄ are values of C₁, R₃ and R₄. Frequencies (FA and FB). The values of C₁, R₃ and R₄ are varied to alter the FA and FB carrier frequencies. Figures 10C and 10D illustrate addition modulator regulator circuits 20° 20° 30° which can be usite.

tor/demodulator circuits 20", 20" which can be utilized in the present invention. Figure 10C shows an FSK decoder using the 565 interface 109. The loop filter capacitor is chosen to set the proper overshoot on the output and a three-stage RC ladder filter is shown in Figure 10D, another FSK chip, the XR2201 shown in Figure 10D, another FSK chip, the XR2211 111, can be used to demodulate and the XR2207 (not shown) can be used for modulation.

Modem Circuita

Figures 18 and 19 illustrate two complete modem configurations which can be utilized in the present invention. Figure 18 is a spread spectrum transmission and receiver modem. This circuit is suited for communication through high voltage AC and DC power lines and for communication through transformers. The spread spectrum modem can be demodulated in high noise levels.

Figure 19 illustrates a Bi-Polar Shift Keying transmission and receiver modern circuit particularly applicable for phone line and LAN communication. This circuit includes an XR 2123 modulator/demodulator 113, XR2208 Operation Multiplier 115, and DM74193 synchronous up/down counter 117. This circuit requires a smaller bandwidth for communication than FSK because it uses only one carrier frequency while changing sine and cosine waves. The carrier frequency must always be at least 10dB above the noise.

Operational Example

The particular attributes of the apparatus and configurations of the present invention are perhaps best illustrated in view of the following comprehensive example described with reference to Figures 22. This example utilizes most of the coupler configurations and modems discussed above and illustrates how the communications apparatus and novel couplers of the present invention can be utilized in a comprehensive system using LAN, phone line, high voltage and low voltage power line communications, as well as communication through power line trans-

miles) power syst m communication, especially ov r high voltag p wer lines. Suitable transistors 66 for this transmitter are conventional SK3444, while the transistors 68 may suitably comprise conventional SK3024. For higher pow r transmission, SM3025 transistors may be utilized instead of SK3024. The particular value of each resistor and capacitic operating in Fig. 11 will depend upon the specific operating characteristics of the driver but they would be readily ascertainable without undue experimentation by one of ordinary skill in the art of electronics. Nevertheless, of ordinary skill in the art of electronics nevertheless, ascertainable without undue experimentation by one of ordinary skill in the art of electronics. Nevertheless, shown in Fig. 11.

out transmission frequencies on the same side. pled to magnetic coil 64 (band pass filter) which filters signal wave. Another feature is the notch filter 79 coupotentiometer 75 which biases out noise around the feature of the receiver of Figure 12 is the inclusion of resistors and capacitors are shown in Fig. 12. A key electronics. Nevertheless, exemplary values of the experimentation by one of ordinary skill in the art of put they would be readily ascertainable without undue specific operating characteristics of the receiver 18, and capacitor shown in Fig. 12 would depend upon tional SK3444. The particular value for each resistor power lines. Suitable transistors 66 are also conventem communication, especially over high voltage powerful for long distance (i.e., 10 miles) power sysily apparent that the receiver means 18, 26 is more tions RFA/B, RFA/BGND and RFA/BC. It will be readpling means 14, 22 by way of their respective connecceiver means 18, 26 is similarly connected to the counals over long distances is shown in Fig. 12. The reuseful in the power-line communications of data sig-The preferred receiver means 18, 26 which is

Figure 12A shows an additional receiver 18', 26' which can be utilized between 120V and 240V including FSK, and which is particularly suited for low voltage LAN and telephone line communications. In this receiver, C_1 and R_1 are used for F1; and C_2 and R_2 are used for F2 in a high pass configuration. In a low pass configuration, C_2 and L_1 are used for F1 and C_4 and notch filter 83 coupled to band pass filter 85 which filters out transmission frequencies.

C. Modulator/Demodulator Circuits

The modulation and demoludation of the data signals is now described with reference to Figures 10A and 10B. Figure 10A illustrates an FM modulator and demodulator 20. This circuit is perticularly applicable for high voltage communication through power-line transformers. The circuit comprises an XR-2211 FSK demodulator 97 XR-2207 FSK generator 99 and MAX232 computer input/output interface 101. The values for computer input/output interface 101. The values for computer input/output interface 101. The values for computer input/output interface 101.

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at a work station may acc as th VAX computer through the power lines of the facility via modems and high speed LAM or phon line couplers of the present invention at data transmission spe ds of up to 10 Khaud

water meter reading. izes the couplers at a second carrier frequency for reading at a first frequency while a water utility utilonely utilized by an electric utility for electric meter the couplers. Hence, the couplers can be simuntaneception of more than one carrier frequency through tion will permit the simultaneous transmission and re-It is to be noted that the couplers of the present inventhrough power line transformers as discussed above. voltage couplers designed for communication In this configuration, the couplers will comprise low 145 and through a three phase large transformer 147. to communicate through two power line transformers the couplers of the present invention can be utilized tem of Figure 22. Figure 25 is a block diagram of how simplified block diagram of the communication sysand through distribution transformers. Figure 24 is a ters at 1200 baud via high voltage distribution lines substations then communicate with the individual meetc.) over conventional phone lines. The respective puter communicates with each substation (1, 2, 3, to a multiplicity of couplers 143. As shown, the commeters via a master modern and multiplexer coupled computer would simultaneous read a large number of tiplicity of substations. In this embodiment the central tem which may be utilized by a utility to meter a mul-Figure 23 is a block diagram of an expanded sys-

A final consideration of the present invention is the connection of the apparatus to a three phase power line. Figure 13 illustrates the general case of coupling the apparatus to the power line, phase to ground. In this format, the carrier frequency is undetectable by other phase-ground coupling connections and each phase is isolated from each other for communication purposes. Figure 14 illustrates a special three phase coupling connection to the power line, 3 phases to ground. This system utilizes all three phase es from the power line and ground for communication.

ner, the phases are interconnected for communicating purposes.

Figure 15 illustrates a special two phase coupling connection to the powerline, phase to phase 147. This system utilizes two phases from the power line for communication. The carrier frequency is detected communication. The carrier frequency is detected only on the two phase coupling connection. In this configuration, only the coupled two phases are

other phase-ground coupling connection. In this man-

Figure 16 illustrates a three phase transformer coupling around delta and Y (Wye) transformers 149. This coupling system is generally utilized in Europe. Th carrier frequency is d tectabl on the other pow-

connected for communication purposes.

NV power lines 129 on the utility pole. transformer will be connect to one of the three 13.2 disclosed in Figures 10A, 11 and 12. The distribution ceivers, modulators/demodulator, or modem circuits above. The system will utilize the transmitters, retransformers such as discussed in section A.3. uration capable of communicating through power line house. The couplers will have the low voltage configsituated on the utility pole 127 located adjacent to the nect to the 240 low volt distribution transformer 126 electricity meter 125. The couplers 123 would conaccordance with the present invention coupled to the air coil transmitter and receiver coupler circuit 123 in power from the utility would have a modem 121 and In this xample, each home 119 receiving electric electric power utility for reading home power met rs. of the pr sent inv ntion as they may utilized by an Figure 22 illustrates an example of the couplers

At the other end of the system situated at a local substation 131, a second substation modem 133 is connected to one of three couplers 135 in accordance with the present invention. The couplers are encased in resin, as disclosed above, and will preferably have the high voltage side transformer configuration set forth in Figure 9C. The substation is itself connected via couplers 137 such as disclosed in section A.1 to the large central computer 139 of the utility (generally a VAX) via phone lines. The substation 131 and computer 139 will communicate via high speed communier 139 will communicate via high speed communicate up to 10K baud as set forth herein using the at rates up to 10K baud as set forth herein using the transmitter, receiver and modulatory demodulator circuits of Figs. 10B, 11 and 12A.

The system only requires between one and ten watta tion coupler 135 and to the substation modern 135. the 13.2 KV power line 129 to the appropriate substaplers 123, through distribution transformer 126, over ed, transmitted by the home modem 121 through couplets 123 and modern 121. A meter reading is recordthe distribution transformer, through the home couthe 13.2 KV line at speeds up to 1200 baud, through dem and couplers. The command is transmitted over addressable command the particular meter via mophone lines 138. The substation will then transmit an speeds up to 10K baud over power or conventional 141 and coupler 137 to the particular substation at command which is transmitted via a master modem the central computer 139 will issue an addressable When the utility desires to make a meter reading,

From the substation, the meter reading may be transmitted via conventional phone lines 138 to the central computer 139. Additionally, as shown in Figure 22A the high speed phone line and LAN couplers of the present invention could be used within the utility to connect local workstations 141 to the central ity to connect local workstations 141 to the central comput r 139. For exampl, a clerical work r situat d

for power transmission in both directions.

- L The communication apparatus of daim 1, further charact rized by
- second coupler m ans (22) conn cted to said electrical line (12),
 demodulator means (28) for demodulating said pres lected carrier frequency signal,
- and receiver means (26) coupled to said second coupler means (22) for conducting said modulated carrier signal to said demodula-
- tor means (28), said second coupler means (22) including in said second coupler means combination a second sir-core transformer means (44) and a second LC circuit (32) that provides an input impedance which corresponds to the characteristic output impedance of the electrical line (12) at said predance of the electrical line (12) at said predance of the electrical line (12).
- 5. The communication apparatus according to claim 2, characterized
- by the ratio of the number of turns of said primary winding (38) to said secondary winding (40) is about one to one.

selected high band carrier frequency.

- 6. The communication apparatus according to claim 2, characterized by
- the combination of the capacitance created between said primary winding (38) and said secondary winding (40) of said sir-core transformer means (36) functioning as a high-pass filter.
- The communication apparatus of daim 4 characterized by
- said second sir-core transformer means (44) having a primary winding (46) having a first diameter, said primary winding (46) being coupled to said capacitor means (42) and
- a secondary winding (48) having a second smaller diameter, said secondary winding (48) extending coaxially within said primary winding (46) such that an air gap is created between said primary winding (46) and said secondary winding (48).
- 8. The communication apparatus according to claim 1, characterized by
 said high band frequency being less than

about 1 MHz.

- The communication apparatus according to claim 1, characterized by
 said high band frequency being less than
 said high band frequency being less than
- said high band frequency being less than about 160 KHz.
- 10. Th communication apparatus according to

er lin . In this mann r, tw different high voltag power lin s are connected to ach other for communication purposes. Finally, Figure 17 illustrat s a one phase transformer coupling which is gen rally used in the U.S.A. In this manner, th carrier frequency is detectabl on the oth r power lin . Accordingly, two different high voltage power lines are connected to each lines are connected to each lines are connected to each li

It is to be understood, therefore, that within the scope of the appended claims, the present invention may be practiced otherwise than as specifically described herein.

Claims

- Communication apparatus comprising

 coupler means (14,22), connected to an
- electrical line (12), having a characteristic output impedance,
- said coupler means (14,22) including transformer means (36)
- characterized by presency signal having a preselected carrier frequency signal having
- a high band frequency,

 transmitter means (16,24) coupled to said
 modulator means (20,28) for transmitting
 said modulated carrier signal to said cou-
- pler means (14,22), said transformer means (36) being sir-core
- transformer means, said air-core transformer means (36) being arranged in combination with capacitor means (34) forming an LC-circuit (30) that provides an input impedance which coresponds to the characteristic output impedance of the electrical line (12) at said predance of the electrical line (13) at said predance line (13) at said predance line (14) at said predance line (15) at said
- 2. The communication apparatus of claim 1, char-

selected high band carrier frequency.

- acterized by

 said sir-core transformer means (36) including a primary winding (38) having a first dismeter and coupled to said capacitor
- means (34), and

 a secondary winding (40) having a second smaller diameter and extending coaxially within said primary winding (38) such that an air gap is created between said primary winding and said secondary winding.
- 3. The communication apparatus of daim 1 characterized by
- esid sir-core transformer means (36) functioning as a phase linear inductively and capacitively coupled transformer.

first r c iv rmeans (26) for modulating signals nals to be carri d by said first carri r frequency and f r demodulating said signals carried by said s cond carrier frequency, asid s cond coupl r means (22) including - said s cond coupl r means (22) including

two LC circuits (34,42), coupled to said

- electrical line (12),

 both said LC circuits (34,42) including capacifor means (34) and resistor means (35),
 consisting of at least one capacitor and at least one resistor, connected in parallel to each other and in series between the electrical line (12) and the primary induction winding (46) of said air-core transformer
- means (44), second transmitter means (24), coupled to said second coupling means (22) of the second said second coupling means (44) for transmitting te transformer means (44) for transmitting signals carried by a second carrier frequent
- cy across the electrical line.(12), second receiver means (18), connected to second second coupling means (22) at the secondsry winding (40) of said sir-core transformer means (36) that is not connected to said transmitter means (24) for receiving signals carried by a first carrier frequency from the electrical line.(43)
- from the electrical line (12), a second modem means (23), coupled between said second transmitter means (24) and said second receiver means (18) for demodulating said signals to be carried by said tirst carrier frequency and modulating said signals carrier frequency.
- 15. The communication apparatus according to claim 14, characterized by
- said LC circuits of said first and second coupler means (14,22) comprising a first plurality of capacitors and a first air coil including primary and secondary windings cluding primary as aid primary winding being the diameter of said primary winding being
- the diameter of said primary winding being greater than the diameter of said secondary winding thereby creating an air core between said primary and secondary winding.
- the other LC circuit being connected in parallel to the electrical line (12) and comprises a second plurality of capacitors and a secondond sir coil including primary and secondary windings, the diameter of said primary winding being greater than the diameter od asid secondary winding thereby creating an air-core between said primary and secondservariables.
- ary windings, wherein said first plurality of capacitors are connected tog the r in parallel between one

daim 4, characterized by

- said high band frequ ncy, measured at a point betw n said receiver means (26) and said second coupler means (22) comprising noise reduction of about twenty d cib is at th band-

11. The communication apparatus according to daim 2 characterized by

- said sir-coils (36,44) comprising impedance matching means such that the primary winding (38) resistivity for transmission and reception at a preselected carrier frequency is about equal to the smallest known characteristic impedance of the electrical line (12).
- 12. The communication apparatus according to daim 1, characterized by
 said coupler means (14,22) resonating at said preselected carrier frequency.
- 13. The communication apparatus of clain 1 characterized by - said transmitter means (16,24) simulta-
- neously transmitting at least a second carrier signal having a second frequency through said coupler means (14,22).
- 14. The communication apparatus according to daims 1 to 4, characterized by
- said first coupler means (14) including two LC circuits (34,42), coupled to said electrical line (12),
 cal line (12),
 poth said 1.C circuite (34.43) including and the couple said 1.C circuite (34.43) including and the couple said 1.C circuite (34.43) including and cou
- both said LC circuits (34,42) including an RC circuit comprised of a capacitor means (34) and a resistor means (35), each consisting of at least one capacitor and at least one resistor, connected in parallel to each one resistor, connected in parallel to each
- said primary winding (38) of said sir-core transformer means (36) being connected in series with said RC circuit and said electrical line (12),
- said first transmitter means (16) being coupled to said first coupler means (14) at the secondary winding (40) of said air-core transformer means (36) for transmitting signals carried by a first carrier frequency across said electrical line (12),
- said first receiver means (26) being coupled to said first coupling means (14) at the secondary winding (48) of the air-core transformer means (44), that is not connected to said transmitter means (16) for receiving signals carried by a second carrier trequency from the electrical line (12),
- a first modem means (21) coupled between said first transmitter means (16) and said

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- 22. The communication apparatus according to claim 14 characterized by
 th capacitanc created b tw n the re-
- in capacitanc created b tw n the respective primary windings (38,46) and secondary windings (40,48) of said air-core transformers (36 and 44) functioning as a high-pass filter with the secondary windings (40,48).
- 23. The communication apparatus according to claim 14 characterized by
 the primary windings (38,46) of said first
- rne primary windings (38,46) of said first and second coupler means (14,22) with said capacitors functioning as a band-pass filter.
- 24 The communication apparatus according to claim 14 characterized by
 said resistors of the first coupler means
 (14) dividing down the AC/DC voltages over said
- 25. The communication apparatus according to claim 14 characterized by
 said resistor(s) of the second coupler

capacitor and resistor circuit.

- means (22) dividing down the AC/DC voltages over said capacitor and resistor circuit.
- 26. The communication apparatus according to claim 24 characterized by

 said capacitors of the first coupler means

 said capacitors of the paraset witeling (39) of
- (14) resonating with the primary winding (38) of said first air-core transformer means (36).
- 27. The communication apparatus according to claim 24 characterized by
 said capacitors of the second coupler
- means (22) resonating with the primary winding (46).
- 28. The communication apparatus of daim 1 characterized by
- said capacitor (34) consisting of at least one capacitor and said coupler means (35) which in ther comprising a resistor means (35) which in combination with said LC circuit (30) forms tirst LC means, said resistor means (35) consisting of at least one resistor, said capacitor means (34) and said resistor means (35) connected in parallel to each other and in series to said electrical line (12).
- 29. The communication apparatus of claim 28 characterized by
- said coupler means (14,22) further comprising a second LC means.
- 30. The communication apparatus of daim 4 charac-

- of th pow r-lines of the electrical line (12) and said primary winding of said first air coil, said primary winding of said first air coil.
- said printingly writefully on said rifet air coil
 th r aft r b ing serially connected t th
 other power-line of said electrical line (12),
 and said secondary winding of said first air
 coil is connected to its respective transmitter means, and
- wherein said second plurality of capacitors
 are serially connected together between
 said one of the power-lines of said electrical
 line (12) and said primary winding of said
 second air coil, said primary winding of said
 second air coil thereafter serially connected
 to the other power-line.
- 16. The communication apparatus according to claim 14, characterized by
 said first and second coupler means
- about 200 KHz.
- 17. The communication apparatus according to claim 14, characterized by
 said first and second coupler means (14,22) each having a bandwidth of less than about 20 KHz.
- 18. The communication apparatus according to daim 14, characterized by
- the induction component of said LC circuits in each of said first and second coupler means (14 and 22) being characterized as comprising two air-core inductors (36 and 44) combined to act as a capacitive air-core transformer which is inductively and capacitively coupled and phase shift linear.
- 19. The communication apparatus according to claim 14 characterized by
- the primary and secondary windings of said first and second air-core transformer means (36,44) functioning as an inductively and capacitively coupled transformer.
- 20. The communication apparatus according to daim 14 characterized by
- the ratio of the number of turns of said primary winding (38) to said secondary winding (40) in said first air-core transformer means (36) being about one to one.
- 21. The communication apparatus according to daim 14 characterized by
- the ratio of the number of turns of said primary winding (46) in secondary winding (46) in said second air-core transformer means (44) be-

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eine Modulatoreinrichtung (20, 28) zur Modulation eines vorgewählten Trägertregenezsignals mit einer hohen Frequ nz, eine mit der Modulatoreinrichtung (20, 28)
 eine mit der Modulatoreinrichtung (16, 24) zum übertragen des modulierten Trägersignals

- auf die Kopplereinrichtung (14, 22), die Übertragereinrichtung, senlose Übertragereinrichtung, die eisenlose Übertragereinrichtung (36) ist
- die eisenlose Übertragereinrichtung (36) ist in Kombination mit einer Kondensatoreinrichtung (34) zur Bildung eines LC-Kreises (30) angeordnet, der eine Eingangsimpedanz bereitsteilt, die der charakteristischen danz bereitsteilt, die der charakteristischen danz bereitsteilt, die der charakteristischen (12) bei der vorgewählten hohen Trägertrequenz entspricht.

Kommunikationseinrichtung nach Anspruch 1, gekennzeichnet durch

- die eisenlose Übertragereinrichtung (36), umfaßt eine Primärwicklung (38), die einen ersten Durchmesser aufweist und die mit der Kondensatoreinrichtung (34) gekoppelt ist, und
- ist, und
 eine Sekundärwicklung (40), die einen
 zweiten kleineren Durchmesser aufweist
 und die sich koaxial innerhalb der Primärwicklung (38) so erstreckt, daß ein Luftspalt zwischen der Primärwicklung und der
 Sekundärwicklung gebildet ist.
- 3. Kommunikationseinrichtung nach Anspruch 1, gekennzeichnet durch
- gekenntzerchniet durch - die eisenlose Übertragereinrichtung (36) wirkt als phasenlinearer induktiv und kapazitiv gekoppelter Übertrager.
- Kommunikationseinrichtung nach Anspruch 1, ferner gekennzeichnet durch
- eine zweite mit der Elektrizitätsleitung (12), verbundene Kopplereinrichtung (22),
- verbundene Koppiereinrichtung (22),
 eine Demodulatoreinrichtung (28) zur De- modulation des vorgewählten Trägerfre-
- quenzsignals, und
 eine mit der zweiten Kopplereinrichtung
 (22) gekoppelte Emptangseinrichtung (26)
 zum Übertragen des modulierten Trägersignals zu der Demodulatoreinrichtung (28),
 die zweite Kopplereinrichtung (22) umfaßt
 in Kombination eine zweite eisenlose übertragereinrichtung (44) und eine zweite Kondensatoreinrichtung (44) zur Bildung eines
- in Kombination eine zweite eisenlose übertragereinrichtung (44) und eine zweite Kondensatoreinrichtung (42) zur Bildung eines zweiten LC-Kreises (32), der eine Eintampedanz bereitstellt, die der charaktersten Ausgangsimpedanz der Elektraktischen Ausgangsimpedanz der Elektraktisteleitung (12) bei der vorgewählten Inägerfrequenz entspricht.

terized by

- said capacitor m ans (34) of said second
coupl r means (22) consisting 1 at least one capacitor and said second coupler m ans (22) further comprising a resistor m ans (35) which in combination with second LC circuit (35) forms a third LC means, said resistor means (35) consisting of at least one resistor, said capacitor means (34) and said resistor means (35) connected in parallel to each other and in series to said electrical line (12).

- 31. The communication apparatus of claim 30 characterized by
 said second coupler means (22) further comprising a fourth LC means.
- 32. The communication apparatus of claim 29 characterized by
 said first LC means and said second LC
 means connected in parallel to said electrical line
- 33. The communication apparatus of claim 32 characterized by
 said third LC means and said fourth LC means connected in parallel to said electrical line
- 34. The communication apparatus of claim 32 character acterized by
 said third LC means and said fourth LC
 means connected in parallel to said electrical line
- 35. The communication apparatus of claim 14 characterzed by
- actented by

 said two LC circuits (34,42) of said first
 coupler means (14) connected in parallel to said
 electrical line (12).
- 36. The communication apparatus of claim 14 characterized by

 said two LC circuits (34,42) of said second coupler means (22) connected in parallel to said electrical line (12).

Patentansprüche

- Kommunikationseinrichtung enthaltend:
 - eine mit einer Elektrizitätsleitung (12) verbundene Kopplereinrichtung (14, 22) mit elner charakteristischen Ausgangsimpener charakteristischen Ausgangsimpedanz,
- wobel die Kopplereinnichtung (14, 22) eine Übertragereinnichtung (36) umfaßt,

gekennzeichnet durch

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gekennzeichnet durch - die Kopplereinrichtung (14, 22) schwingt

mit b i der vorgewählten Trägerfrequenz.

- 13. Kommunikationseinrichtung nach Anspruch 1, gek_nnzeichnet durch
- die Sendeeinrichtung (16, 24) überträgt gleichzeitig wenigstens ein zweites Trägersignal mit einer zweiten Frequenz durch die Kopplereinrichtung (14, 22).
- 14. Kommunikationseinrichtung nach den Ansprüchen 1 bis 4, gekennzeichnet durch
- die erste Kopplereinrichtung (14) umfaßt zwei LC-Kreise (34, 42), die mit der Elektrizitätsleitung (12) gekoppelt sind,
- beide LC-Kreise (34, 42) umfassen einen RC-Kreis mit einer Kondensatoreinrichtung (34) und einer Widerstandseinrichtung (35), wobei jeder aus wenigstens einem Kondensator und wenigstens einem Paral-
- leigeschalteten Widerstand besteht, die Primärwichtung (36) der eisenlosen übertragereinrichtung (36) ist in Reihe geschaltet mit dem RC-Kreis und der Elektri-
- zitätsleitung (12), die erste Sendeeinrichtung (16) ist mit der erste Sendeeinrichtung (14) gekoppelt an der Sekundärwicklung (36) zur Übertrageneinrichtung (36) zur Übertragung von Signalen, die von einer ersten Trägertrequenz über die Elektrizitätsleit
- tung (12) übertragen werden, die erste Emptangseinrichtung (26) ist mit der ersten Kopplereinrichtung (14) gekoppelt an der Sekundärwichtung (48) der eisenlosen übertragereinrichtung (46), die nicht mit der Sendeeinrichtung (16) verbunnicht mit der Sendeeinrichtung (16) verbunnicht mit der Sendeeinrichtung (16) verbunnicht mit der Sendeeinrichtung (16) verbunden ist, zum Emptangen von Signalen, die von einer zweiten Trägertrequenz über die Elektrizitätsleitung (12) übertragen wer-
- eine erste Modulationseinrichtung (21), die zwischen die erste Sendeeinrichtung (26) zur und die erste Empfangseinrichtung (26) zur Modulation von Signalen eingekoppelt ist, die von der ersten Trägerfrequenz zu übertragen sind, und zur Demodulation von den Signalen, die von der zweiten Trägerfre-Signalen, die von der zweiten
- quenz übertragen werden, die zweite Kopplereinrichtung (22) umfaßt zwei LC-Kreise (34, 42), die mit der Elektrizitätsleitung (12) gekoppelt sind,
- beide LC-Kreise (34, 42) unfassen eine Kondensatoreinrichtung (34) und eine Widensatoreinrichtung (35), die aus wenigstens einem Kondensator und wenigstens einem parall Igeschalt ten Widerstand beeinem parall Igeschalt ten Widerstand be-

- Kommunikationseinrichtung nach Anspruch 2,
 g kennzeichnet
 durch das V rhältnis der Windungszah len der Primärwicklung (38) zu der Sekundärwic-
- Kommunikationseinrichtung nach Anspruch 2, gekennzeichnet durch
 die Kombination der Kapazität, die zwi-

Klung (40) ist etwa eins zu eins.

- die Kombination der Kapazität, die zwischen der Primärwicklung (38) und der Sekundärwicklung (40) der eisenlosen Übertragereinrichtung (36) gebildet wird, wirkt als Hochpasstillter.
- 7. Kommunikationseinrichtung nach Anspruch 4, gekennzeichnet durch
- die zweite eisenlose Übertragereinrichtung (44) weist eine Primärwicklung (46) mit eine nem ersten Durchmesser auf, wobei die Primärwicklung (46) mit der Kondensatoreinrichtung (42) verbunden ist, und richtung (42) verbunden ist, und
- nchtung (42) verbunden ist, und einem eine Sekundärwicklung (48) mit einem zweiten kleineren Durchmesser, wobei sich die Sekundärwicklung (48) koaxial innerhalb der Primärwicklung (46) so erstreckt, daß ein Luftspalt zwischen der Primärwicklung (48) und der Sekundärwicklung (48) gebildet ist.
- kommunikationseinnchtung nach Anspruch 1, gekennzeichnet durch
 die Hochfrequenz ist niedriger als etwa 1

ZHM.

- Gommunikationseinrichtung nach Anspruch 1,
- die Hochfrequenz ist niedriger als etwa
- 10. Kommunikationseinrichtung nach Anspruch 4, 40 gekennzeichnet durch
- die Hochfrequenz gemessen an einem Punkt zwischen der Empfangseinrichtung (26) und der zweiten Kopplereinrichtung (22) weist eine Störuntierdrückung innerhalb der Bandbreite non etwa zwanzig Dezibel auf.
- 11. Kommunikationseinhchtung nach Anspruch 2, gekennzeichnet durch
- die Luftspulen (36, 44) umfassen Impedanzanpassungseinrichtungen, so daß der spezifische Widerstand der Primärwicklung (38) zum Senden und Empfangen bei einer vorgewählten Trägerfrequenz etwa gleich ist der kleinsten Dekannten charakteristischen Impedanz der Elektrizitätsleitung (12).
- 12. Kommunikationseinrichtung nach Anspruch 1,

wicklung d r ersten Luftspule ist mit s iner ntsprechend n S nd inrichtung verbun-

- wobel die zweite Mehrzahl von Kondensawobel die zweite Mehrzahl von Kondensatoren mit inander in Reih g schalt t ist zwischen der einen Stromversorgungsleitung der Elektrizitätsleitung (12) und der Primärwicklung der zweiten Luftspule, wobei die Primärwicklung der zweiten Luftspule anschließend in Reihe geschaltet ist spule anschließend in Reihe geschaltet ist mit der anderen Stromversorgungsleitung.

16. Kommunikationseinrichtung nach Anspruch 14.

 die erste und zweite Kopplereinrichtung (14, 22) weisen jeweils eine Bandbreite von weniger als etwa 200 kHz auf.

17. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch

 die erate und zweite Kopplereinrichtung (14, 22) weisen jeweils eine Bandbreite von weniger als etwa 20 kHz auf.

gekennzeichnet durch
gekennzeichnet durch
14,

 die induktive Komponente det LC-Kreise in jeder der ersten und zweiten Kopplereinrichtung (14 und 22) ist gekennzeichnet durch Enthalten von zwei eisenlosen Induktionsspulen (36 und 44), die kombiniert sind, um als kapazitiver eisenloser Übertrager zu wirken, der induktiv und kapazitiv gekoppelt und phasenverschiebungslinear ist.

 Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch

- die Primär- und Sekundärwicklungen der ersten und zweiten eisenlosen Übertragereinrichtungen (36, 44) wirken als induktiv und kapszitiv gekoppelter Übertrager.

20. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch

- das Verhältnis der Zahl der Windungen der Primärwicklung (38) zu der Sekundärwicklung (40) in der ersten eisenlosen Übertragereinrichtung (36) beträgt etwa eins zu eins.

3ekennzeichnet durch 31° Kommunikationseinrichtung nach Ansbruch 14°

 das Verhältnis der Zahl der Windungen der Primärwicklung (46) zu der Sekundärwicklung (48) in der zweiten eisenlosen Übertragereinrichtung (44) beträgt etwa eins zu eins.

22. Kommunikationseinrichtung nach Anspruch 14, g kennz ichnet durch

atehen und in Reih zwischen di Elektrizitätsleitung (12) und di Primärinduktionswicklung (46) der eisenlosen Übertragereinrichtung (44) geschaltet sind,

- ine zweit S nde inrichtung (24), die mit der zweiten Kopplereinrichtung (22) der Sekundärinduktionswicklung (48) der eisenlosen Übertragereinrichtung (44) zum Übertragereinrichtung (44) zum Übertragereinrichtung (44) zum Elektrizitätsleitragen von Signalen, die Elektrizitätsleitung (12) übertragen werden, gekoppelt ist, eine zweite Emptangseinrichtung (18), die mit der Zweiten Kopplereinrichtung (18), die der Sekundärwicklung (40) der eisenlosen der Sekundärwichtung (36) verbunden ist, die nicht mit der Sendeeinrichtung (24) verdie nicht mit der Sendeeinrichtung (25) verdie nichtung (25) verdie nich

len von der Elektrizitätsleitung (12), eine zweite Modulationseinrichtung (23), die zweite Modulationseinrichtung (24) und die zweite Empfangseinrichtung (18) zur Demodulation der Signale, die von der ersten Trägerfrequenz zu übertragen sind, und zur Modulation von den Signalen, die von der zweiten Trägerfrequenz übertragen werden, eingekoppelt ist.

15. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch

die LC-Kreise der ersten und zweiten Kopplereinnrchtung (14, 22) umfassen eine erste Mehrzahl von Kondensatoren und eine erste Luftspule mit Primär- und Sekundärwicklungen,

 der Durchmesser der Primärwicklung ist größer als der Durchmesser der Sekundärwicklung und erzeugt dadurch einen Luftkern zwischen den Primär- und Sekundär-

wickdungen,

der andere LC-Kreis ist parallel zu der Elektirizitätsleitung (12) geschaltet und umfaßt eine zweite Mehrzahl von Kondensatoren und eine zweite Luftspule mit Primär- und Sekundärwicklung enßer ist als messer der Primärwicklung größer ist als der Durchmasser der Sekundärwicklung und dadurch einen Luftkern zwischen den Primär- und Sekundärwicklungen erzeugt, wobei die erste Mehrzahl von Kondensatowobei die erste Mehrzahl von Kondensatoren mitsinander parallelgeschaltet sind zwieren mitsinander parallelgeschaltet sind zwischen einer der Stromversorgungsleitungen einer der Stromversorgungsleitungen einer der Stromversorgungsleitungschen einer der Stromversorgungsleitungsche der Stromversorgungsche der Schen einer der Stromversorgungsche der Stromversorgungsche der Stromversorgungsche der Schen einer der Stromversorgungsche der

gen der Elektrizitätaleitung (12) und der Primärwicklung der eraten Luftapule ist die Primärwicklung der eraten Luftapule ist anschließend in Reihe geschaltet mit der anschließend in Stromversorgungsleitung der anderen Stromversorgungsleitung der

Elektrizitätsleitung (12) und di Skundär-

30. Kommunikationseinrichtung nach Anspruch 4, gekennzeichn t durch

- die Kond nastoreinrichtung (34) der zweiten Kopplereinrichtung (22) besteht aus wenigst ns einem Kond nastor und di zweite Kopplereinrichtung (22) umfaßt ferner eine Widerstandseinrichtung (35), die in Kombination mit einem zweiten LC-Kreis (32) eine dritte LC-Anordnung bildet, wobei die Widerstandseinrichtung (35) aus wenigstens einem Widerstand betung (35) aus wenigstens einem Widerstand betung (35) aus wenigstens einem Widerstand besteht, wobei die Kondensatoreinrichtung (34) und die Widerstandseinrichtung (35) zueinander parallel und in Reihe zu der Elektrizitätsleitung (12) geschaltet sind.

- 31. Kommunikationseinrichtung nach Anspruch 30, gekennzeichnet durch
 die zweite Kopplereinrichtung (22) um-
- faßt ferner eine vierte LC-Anordnung.
- 32. Kommunikationseinrichtung nach Anspruch 29, gekennzeichnet durch - die erste LC-Anordnung und die zweite
- LC-Anordnung sind parallel zu der Elektrizitätsleitung (12) geschaltet.
- 33. Kommunikationseinrichtung nach Anspruch 32, gekennzeichnet durch
 gekennzeichnet durch
 die dritte LC-Anordnung und die vierte
- LC-Anordnung sind parallel zu der Elektrizitätaleitung (12) geschaltet
- 34. Kommunikationseinrichtung nach Anspruch 32, gekennzeichnet durch
- die dritte LC-Anordnung und die vierte LC-Anordnung sind parallel zu der Elektrizitätsleitung (12) geschaltet.
- 35. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch
- die beiden LC-Kreise (34, 42) der ersten Kopplereinrichtung (14) sind parallel zu der Elektrizitätsleitung (12) geschaltet.
- 36. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch
- die beiden LC-Kreise (34, 42) der zweiten Kopplereinrichtung (22) sind parallel zu der Elektrizitätsleitung (12) geschaltet.

Revendications

1. Dispositif de transmission, comprenant
- des moyens coupleurs (14, 22), reiliés à une
ligne électrique (12), ayant une impédance
de sortie caractéristique,
- lesdits moy ns coupl urs (14, 22) compre-

- di Kapazităt, die zwischen d n ntsprechenden Primārwicklung n (38, 46) und Sekundārwicklungen (40, 48) der eisenlosen Übertrager (36 und 44) erzeugtwird, wirkt mit den Sekundārwicklung n (40, 48) als Hochpasstilter.
- \$3. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch
 die Primärwicklungen (38, 46) der ersten und zweiten Kopplereinrichtung (14, 22) wirkt mit

den Kondensatoren als Bandpassfilter.

- 24. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch - die Widerstände der ersten Konnlerein-
- die Widerstände der ersten Kopplereinrichtung (14) teilen die Gleich-/Wechselspannungen über die Kondensator- und Widerstandsschaltung herab.
- 25. Kommunikationseinrichtung nach Anspruch 14, gekennzeichnet durch
 der oder die Widerstände der zweiten Kopplereinrichtung (22) teilen die GleichWechselspannungen über die Kondensator- und
- 26. Kommunikationseinrichtung nach Anspruch 24, gekennzeichnet durchdie Kondensatoren der ersten Koppler-

Widerstandsschaltung herab.

- einrichtung (14) schwingen mit der-Pimärwicklung (38) der eraten eisenlosen Übertragereinrichtung (36).
- \$7. Kommunikationseinrichtung nach Anspruch 24, gekennzeichnet durch
 die Kondensatoren der zweiten Kopplereinrichtung (22) schwingen mit der Pimärwicklung (46) des zweiten eisenlosen
- **28.** Kommunikationseinrichtung nach Anspruch 1, gekennzeichnet durch

Ubertragers (44).

- der Kondensator (34) besteht aus wenigstens einem Kondensator und die Kopplereinrichtung (14) umfaßt ferner eine Widerstandseinrichtung (35), die in Kombination mit dem LC-Kreis (30) eine erste LC-Anordnung bildet, wobei die Widerstandseinrichtung (35) aus wenigstens einem Widerstand besteht, wobei die Kondensatorem Widerstand besteht, wobei die Kondensatoreinrichtung (34) und die Widerstandseinrichtung (35) zueinander paraillel und in Reihe zu der Elekträtätsleitung (12) geschaltet sind.
- 29. Kommunikationseinrichtung nach Anspruch 28, gekennzeichnet durch
- die Kopplereinrichtung (14, 22) umfaßt ferner eine zweite LC-Anordnung.

teuse d bande él vée présélectionnée. ligne él ctrique (12) à ladite fréquence porl'impédance de sortie caractéristique de la

- 2, caractérisé en ce que Dispositif de transmission selon la revendication
- condaire (40) est d'environ un pour un. roulement primaire (38) audit enroulement se-- le rapport du nombre des spires dudit en-
- 2, caractérisé en ce que Dispositif de transmission selon la revendication
- teur à air (36) fonctionne comme un filtre passelement secondaire (40) dudit moyen transformatre ledit enroulement primaire (38) et ledit enrou-- la combinaison de la capacité, créée en-
- 4, caractérisé en ce que Dispositif de transmission selon la revendication
- neyom tibus élier fraté (64) enisminq fram ayant un premier diamètre, ledit enroule-(44) comporte un enroulement primaire (46) - ledit second moyen transformateur à air
- et ledit enroulement secondaire (48). d'air entre ledit enroulement primaire (46) primaire (46) de manière à créer un espace re coaxiale à l'intérieur dudit enroulement ment secondaire (48) s'étendant de manièsecond diamètre plus petit, ledit enrouleun enroulement secondaire (48) ayant un formant condensateur (42), et par
- 1, caractérisé en ce que 8. Dispositif de transmission selon la revendication
- ladite fréquence de bande élevée est in-
- férieure à environ 1 MHz.
- 1, caractérisé en ce que Dispositif de transmission selon la revendication
- ladite fréquence de bande élevée est in-
- férieure à environ 160 KHz.
- 4, caractérisé en ce que 10. Dispositif de transmission selon la revendication
- la largeur de bande. une réduction du bruit d'environ vingt décibels à et ledit second moyen coupleur (22) comporte rée en un point entre ledit moyen récepteur (26) - ladite fréquence de bande élevée, mesu-
- 2, caractérisé en ce que 11. Dispositif de transmission selon la revendication
- dneuce borteus brésél cti uné soit à peu près pour l'émission et pour la réception à une fréque la résistivité de l'enroulement primaire (38) nent un moyen d'adaptation d'impédance afin - lesdites bobines à air (36, 44) compren-

caractériaé par nant un moyen transformateur (36),

l ctionnée ayant un fréquenc de band duler un signal à fréquence porteus présé-des moyens modulateurs (20, 28) p ur mo-

- transmettre ledit signal à porteuse modulée dits moyens modulateurs (20, 28) pour des moyens émetteurs (16, 24), reliés aux-
- transformateur à air, et ledit moyen transformateur étant un moyen suxdits moyens coupleurs (14, 22),
- lectionnée. dneuce bortenze de pande élevée préséque de la ligne électrique (12) à ladite frépond à l'impédance de sortie caractéristiassure une impédance d'entrée, qui correscircuit LC (à inductance et capacité) (30) qui formant condensateur (34) constituant un disposé en combinaison avec un moyen ledit moyen transformateur à air (36) étant
- 1, caractérisé en ce que Dispositif de transmission selon la revendication
- dit moyen formant condensateur (34), et ayant un premier diamètre et étant relié aucomprend un enroulement primaire (38) - ledit moyen transformateur à air (36)
- espace d'air entre ledit enroulement primaiment primaire (38), de manière à créer un nière coaxiale à l'intérieur dudit enroulesecond diamètre plus petit, s'étend de ma-- un enroulement secondaire (40), ayant un
- 1, caractérisé en ce que 3. Dispositif de transmission selon la revendication

re et ledit enroulement secondaire.

- couplage de phase par induction et par capacité. fonctionne comme un transformateur linéaire à - ledit moyen transformateur à air (36)
- 1, caractérisé en outre par Dispositif de transmission selon la revendication
- te ligne électrique (12), un second moyen coupleur (22) relié à ladi-
- lectionnée, et ler ledit signal à fréquence porteuse présé-un moyen démodulateur (28) pour démodu-
- démodulateur (28), et signal à porteuse modulée vers ledit moyen moyen coupleur (22) pour acheminer ledit un moyen récepteur (26), relié audit second
- un impédance d' ntrée, qui correspond à tuant un second circuit LC (32) qui assure moyen formant condensateur (42), constitransformateur à air (44) et un second nant en combinaison un second moyen ledit second moyen coupleur (22), compre-

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nent un moyen formant condensateur (345), et un moyen formant résistanc (355), consistant en au moins un cond neateur et au moins un résistance, montés en paral·lèl l'un à l'autr et en série entr la lign électrique (12) et l'enroulement primaire à électrique (12) et l'enroulement primaire à sir (44),

- le second moyen émetteur (24) est relié audit second moyen coupleur (22) de l'enroulement secondaire à induction (48) dudit transformateur à sir (44) afin d'émettre des signaux portés par une seconde fréquence signaux portés par une seconde fréquence
- porteuse, sur la ilgne électrique (12), un second moyen récepteur (18) est relié sudit second moyen coupleur (22) au niveau de l'enroulement secondaire (40) dudit moyen transformateur à sir (36), qui n'est pas relié audit moyen émetteur (24), n'est pas relié audit moyen émetteur (24), atin de recevoir de la ligne électrique (12) des signaux portés par une première frédes signaux productions que signaux que signaux productions que signaux qu
- quence porteuse, et un second moyen formant modem (23), étant monté entre ledit second moyen récepéant (24) et ledit second moyen récepteur (18) afin de démoduler lesdits signaux à porter par ladite première fréquence porteuse et de moduler lesdits signaux portés porter et de moduler lesdits signaux portés par ladite seconde fréquence porteuse.

15. Dispositif de transmission selon la revendication 14, caractérisé en ce que

- lesdits circuits LC desdits premier et second moyens coupleurs (14, 22) comprennent une première pluralité de condenasteurs et une première bobine à air comprenant des enroulements primaire et seconnant des enroulements primaire et secondeire
- le dismètre dudit enroulement primaire est supérieur su dismètre dudit enroulement secondaire, pour ainsi créer un espace d'air entre lesdits enroulements primaire et se-
- l'autre circuit LC est monté en parailèle à la sulte circuit LC est monté en parailèle à ligne électrique (12) et comprenant une seconde plurailité de condensateurs et une seconde conde bobine à sir, comprenant des enroulements primaire étant supérieur dudit enroulement primaire étant supérieur au dismètre dudit enroulement secondaire pour ainsi créer un espace d'air entre lescondaire dits enroulements primaire et secondaire, dans lequel ladite première plurailité de dans lequel ladite première plurailité de condensateurs sont montés ensemble en condensateurs aont montés ensemble en pertilélé, entre l'une des lignes de transport d'énergie de la lignes électrique (12) et ledit enroulement primaire de ladite première detit en le ledit en première de la ladite première de la ladite première de la ladite première de la ladite première.

re bobine à air,

égal à la plus p tite impédanc caractéristique connu d la lign électrique (12).

- 12. Dispositif de transmissi n s lon la revendication 1, caractérisé en ce qu lesdits moyens coupleurs (14, 22) résonnent à ladite fréquence porteuse présélectionnent à ladite fréquence
- 13. Dispositif de transmission selon la revendication
 1, caractérisé en ce que
 leadits moyens émetteurs (16, 24) émet leadits moyens émetteurs (16, 24) émet-
- results moyens emetreurs (10, 24) emettent simultanément au moins un second signal à porteuse ayant une seconde fréquence, par l'intermédiaire desdits moyens coupleurs (14, 22).
- 14. Dispositif de transmission selon les revendications 1 à 4, caractérisé en ce que - ledit premier moyen coupleur (14)
- comprend deux circuits LC (34, 42), reliés à ladite ligne électrique (12), leadits deux circuits LC (34, 42) comprennent un circuit RC (à résistence et caracité)
- nent un circuit RC (à résistance et capacité) nent un circuit RC (à résistance et capacité) composé d'un moyen formant résistance teur (35), chacun consistant en au moins un condensateur et au moins une résistance, montés en parailèle l'un à l'autre,
- ledit enroulement primaire (38) dudit moyen transformateur à sir (36) est relié en série audit circuit RC et à ladite ligne électrique (12),
- ledit premier moyen émetteur (16) est relié sudit premier moyen coupleur (14) au niveau de l'enroulement secondaire (40) dudit moyen transformateur à sir (36) afin de transmettre sur ladite ligne électrique (12) des signaux portés par une première tréquence porteuse,
- ledit premier moyen récepteur (26) est relié audit premier moyen coupleur (14) au niveau de l'enroulement secondaire (48) du moyen transformatieur à air (44), qui n'est pas relié audit moyen émetteur (16), af in de recevoir de la ligne électrique (12) des signaux portés par une seconde fréquence porteuse,
- un premier moyen formant modem (21), étant monté entre ledit premier moyen récepémetteur (16) et ledit premier moyen récepteur (26) afin de moduler des signaux à porber par ladite première fréquence porteuse et de démoduler lesdits signaux portés par ladite seconde fréquence porteuse, ledit second moyen coupleur (22)
- ledit second moyen coupleur (22) comprend deux circuita LC (34, 42), reliés à ladite ligne électrique (2),
- lesdits d ux circuits LC (34, 42) compren-

condsir (48) dans ledit s cond may n transformat ur à sir (44) est d'environ un pour un.

- Dispositif d transmission selon la revendication
 14, caractérisé en ce que
 la capacité créée entre les enroulements
- primaires (38, 46) et les enroulements secondaires (40, 48) respectifs desdits transformateurs à sir (36 et 44) fonctionne comme un filtre passehaut, avec les enroulements secondaires (40, 48)
- 23. Dispositif de transmission selon la revendication 14, caractérisé en ce que
 les enroulements primaires (38, 46) desdits premier et second moyens coupleurs (14, dits premier et second moyens coupleurs (14,
- dits premier et second moyens coupleurs (14, 22), avec leadits condensateurs, fonctionnent comme un filtre passe-bande.
- 24. Dispositif de transmission selon la revendication 14, caractérisé en ce que lesdites résistances du premier moyen coupleur (14) divisent les tensions alternati-
- coupleur (14) divisent les tensions alternatives/continues sur ledit circuit à condensateur et à résistance.
- 25. Dispositif de transmission selon la revendication 14, caractérisé en ce que coupleur (22) divise(nt) les tensions alter-
- natives/continues sur ledit circuit à condensateur et à résistance.
- 26. Dispositif de transmission selon la revendication 24, caractérisé en ce que - lesdits condensateurs du premier moyen
- coupleur (14) résonnent avec l'enroulement primaire (38) dudit premier moyen transformateur à sir (36)
- Dispositif de transmission selon la revendication
 24, caractérisé en ce que
 lesdits condensateurs du second moyen
- coupleur (22) résonnent avec l'enroulement primaire (46) dudit second transformateur à air (44).
- 28. Dispositif de transmission selon la revendication 1, caractérisé en ce que
- ledit condensateur (34) consiste en au moins un condensateur et en ce que ledit moyen coupleur (14) comprend en outre un moyen formant résistance (35) qui, en combinaison avec ledit circuit LC (30), constitue un premier moyen LC, ledit moyen formant résistance (35) consistant condensateur (34) et ledit moyen formant condensateur (34) et ledit moyen formant condensateur (34) et ledit moyen formant résistance (35) étant montés en parallèle l'un à l'autre et en série avec ladite ligne électrique l'autre.

- ledit enroulement primaire d ladit première bobine à sir étant ensuite relié en séri à l'autr ligne d transport d'énergie de ladite ligne électrique (12), et ledit nroul ment secondaire d ladite première bobin à sir étant relié à son moyen émetteur correspondant, et
- dars lequel ladite seconde pluralité de dars lequel ladite seconde condensateurs sont montés ensemble en série entre ladite une des lignes de transport d'énergie de ladite ligne électrique (12) et ledit enroulement primaire de ladite seconde bobine à air, ledit enroulement phrasire de ladite seconde bobine à air étant ensuite relié en série à l'autre ligne de transport d'énergie.
- Dispositif de transmission selon la revendication 14, caractérisé en ce que
 lesdits premier et second movens cou-
- lesdits premier et second moyens coupleurs (14, 22) ont chacun une largeur de bande inférieure à environ 200 KHz.
- Dispositif de transmission selon la revendication 14, caractérisé en ce que
 lesdits premier et second moyens cou-
- pleurs (14, 22) ont chacun une largeur de bande inférieure à environ 20 KHz.
- 18. Dispositif de transmission selon la revendication 14, caractérisé par
- l'élément d'induction desdits circuits LC dans chacun desdits premier et second moyens coupleurs (14 et 22), étant caractérisé en ce qu'il comprend deux bobines d'inductance à sir (36 et 44) combinées pour fonctionner comme un transformateur à sir capacitif, qui est à couplage par induction et par capacité et à déphasage linésire.
- 19. Dispositif de transmission selon la revendication 14, caractérisé en ce que
- les enroulements primaires et secondaires desdits premier et second moyens transformateurs à sir (36, 44) fonctionnent comme un transformateur à couplage par induction et par capacité.
- 20. Dispositif de transmission selon la revendication 14, caractérisé en ce que
- le rapport du nombre de spires dudit enroulement primaire (38) audit enroulement secondaire (40) dans ledit premier moyen transformateur à sir (36) est d'environ un pour un.
- 21. Dispositif de transmission selon la revendication 55 14, caractérisé en ce que
- -ne fibub serides de somon ub rapport el --es finemeluorne fibus (44) risming fin m luor

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électrique (12).
parallèle l'un à l'autre et en série avec ladite ligne
moyen formant résistance (35) étant montés en
ledit moyen formant condensateur (34) et ledit
tance (35) consistant en au moins une résistance,
troisième moyen LC, ledit moyen formant résis-
son avec un deuxième circuit LC (32) forme un
moyen formant résistance (35) qui, en combinai-
moyen coupleur (22) comprend en outre un
moins un condensateur, et en ce que ledit second
dudit second moyen coupleur (22) consiste en au
- ledit moyen formant condensateur (34)
                       4, caractérisé en ce que
30. Dispositif de transmission selon la revendication
   comprennent in outrilling second moy in LC.
- lesdits moyens coupleurs (14, 22)
                       28, caractérisé en ce qu
29. Dispositif de transmission selon la revendication
                         38
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- 31. Dispositif de transmission selon la revendication 30, caractérisé en ce que ledit second moyen coupleur (22)
- ledit second moyen coupleur (22) comprend en outre un quatrième moyen LC.
- 32. Dispositif de transmission selon la revendication 29, caractérisé en ce que - ledit premier moyen LC et ledit deuxième moyen LC sont reliés en parallèle à ladite ligne électrique (12).
- 33. Dispositif de transmission selon la revendication 32, caractérisé en ce que ledit troisième moyen LC et ledit quatrième moyen LC et ledit quatrième moyen LC sont reliés en parallèle à ladite ligne électrique (12).
- 34. Dispositif de transmission selon la revendication 32, caractérisé en ce que ledit troisième moyen LC et ledit quatrième moyen LC sont reliés en parallèle à ladite lib gne électrique (12).
- 35. Dispositif de transmission selon la revendication 14, caractérisé en ce que lesdits deux circuits LC (34, 42) dudit premier moyen coupleur (14) sont reliés en parallèle à ladite ligne électrique (12).
- 36. Dispositif de transmission selon la revendication 50. 14, caractérisé en ce que lesdits deux circuits LC (34, 42) dudit second moyen coupleur (22) sont reliés en parallèle à ladite ligne électrique (12).

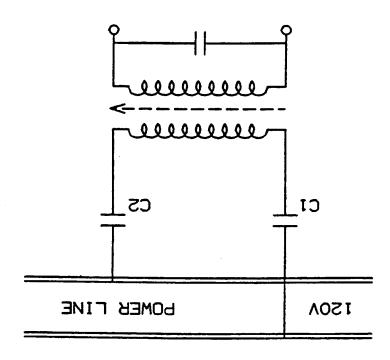
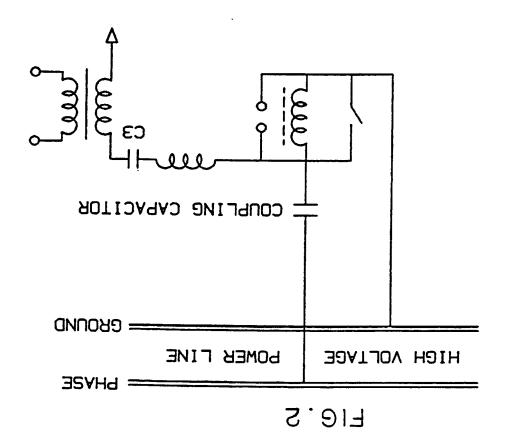
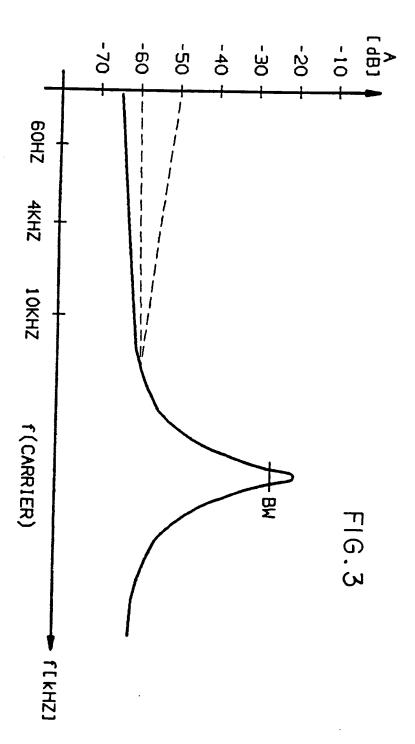
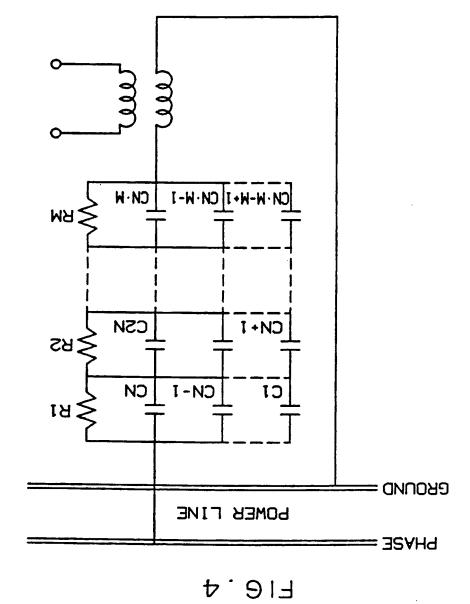
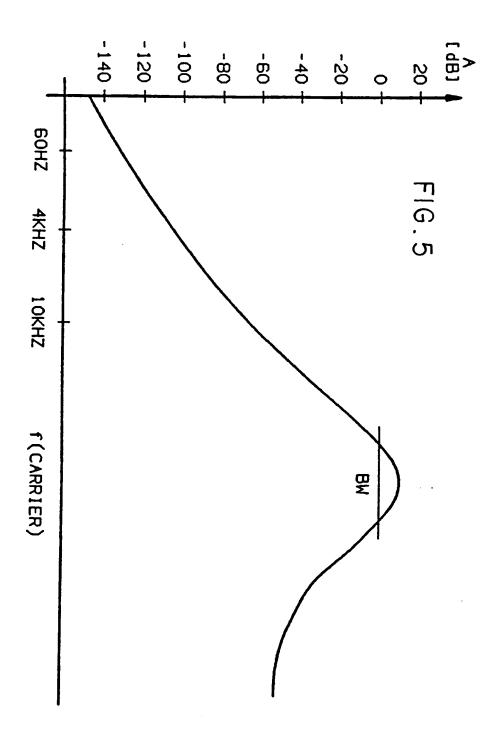


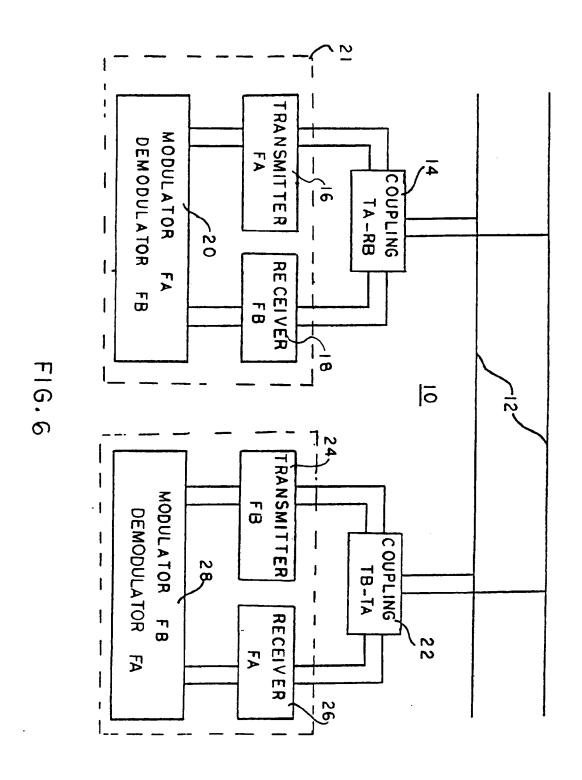
FIG.I



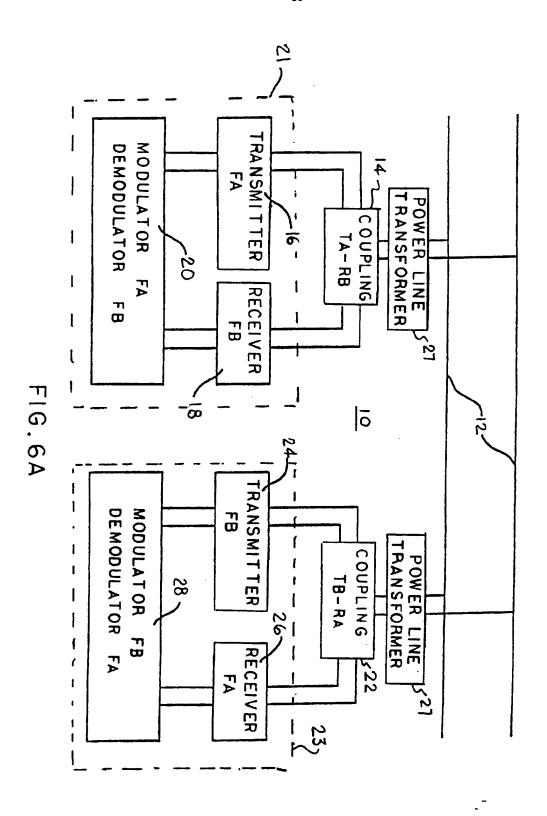




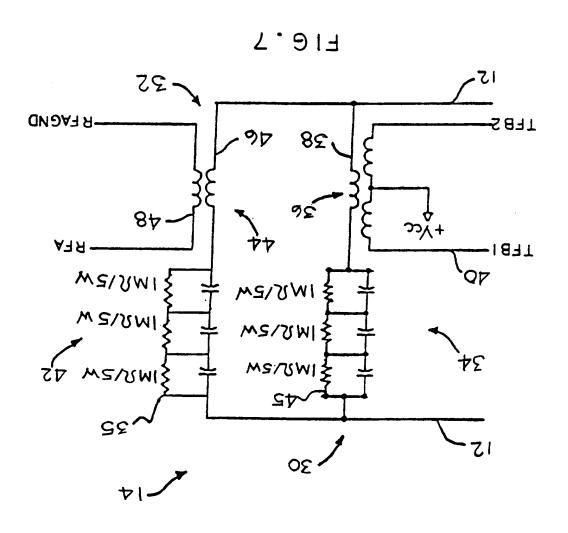




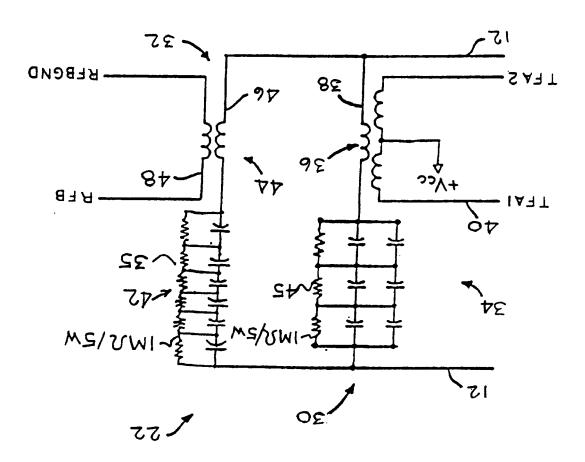
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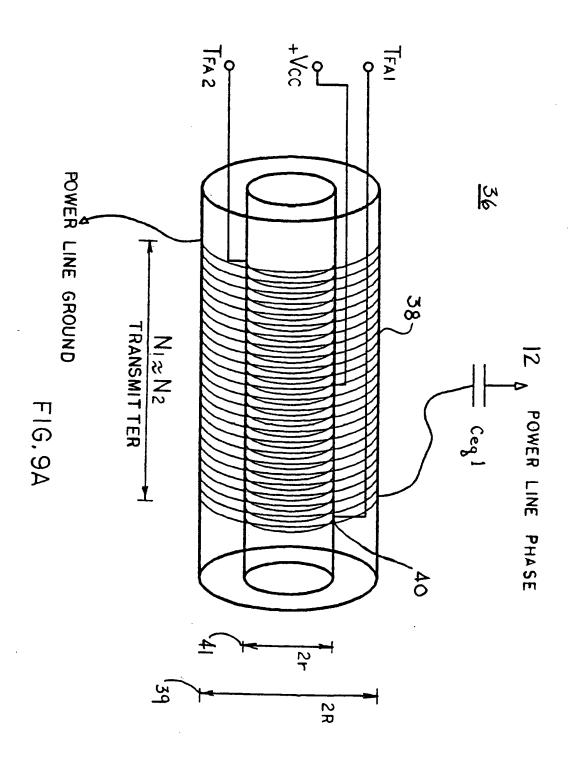


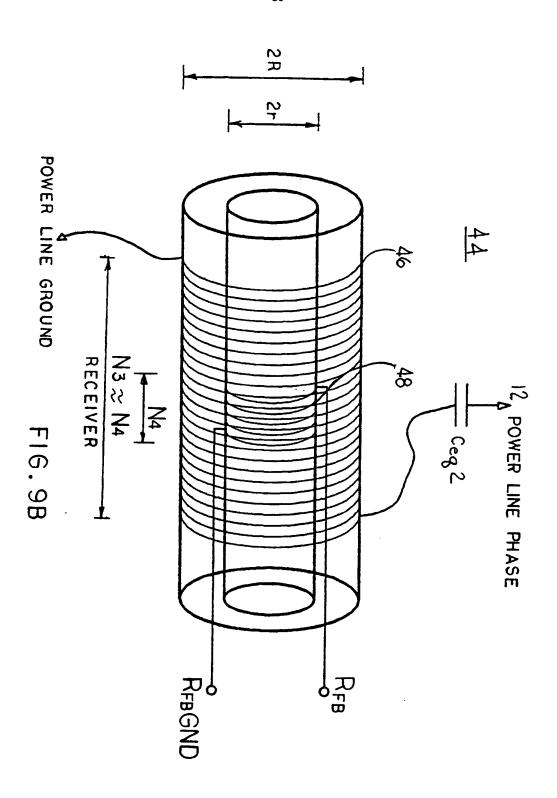
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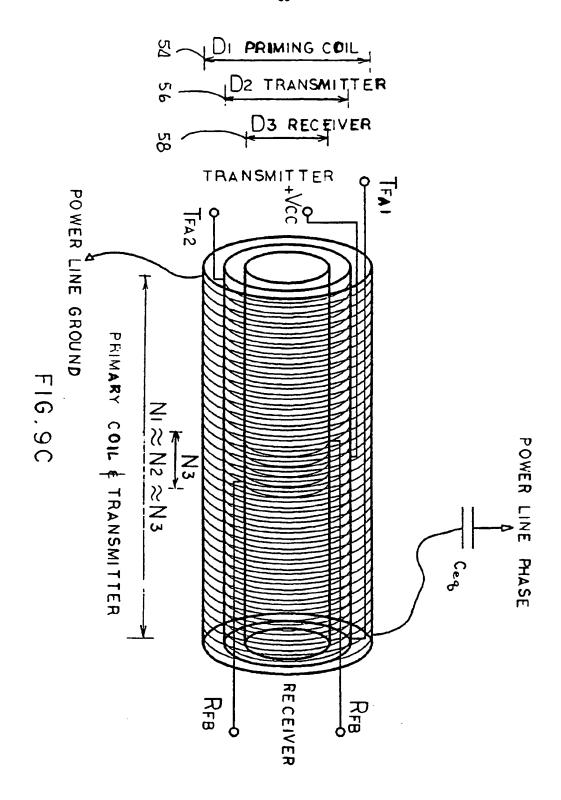


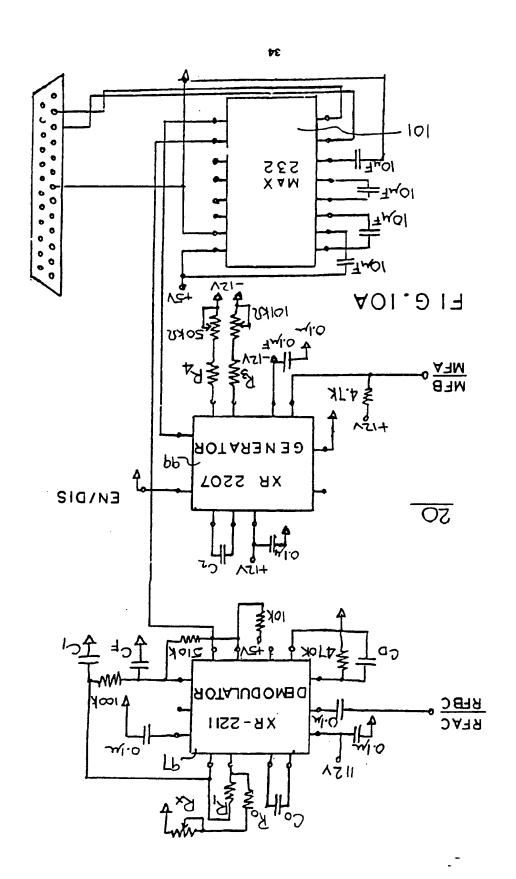


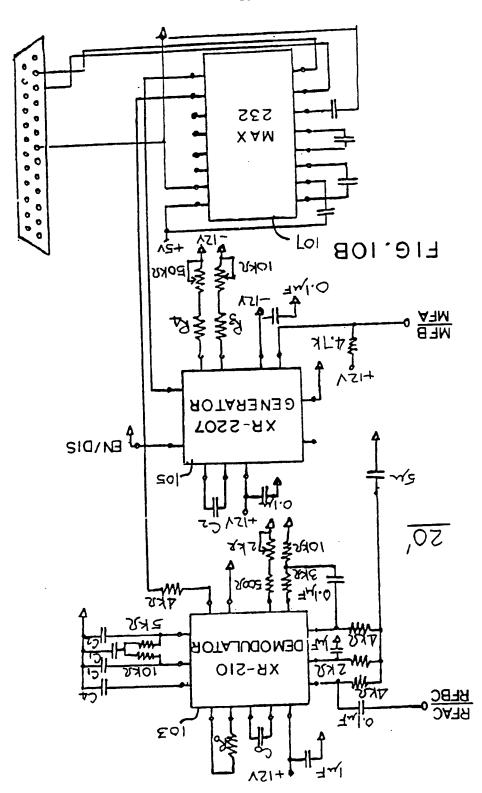




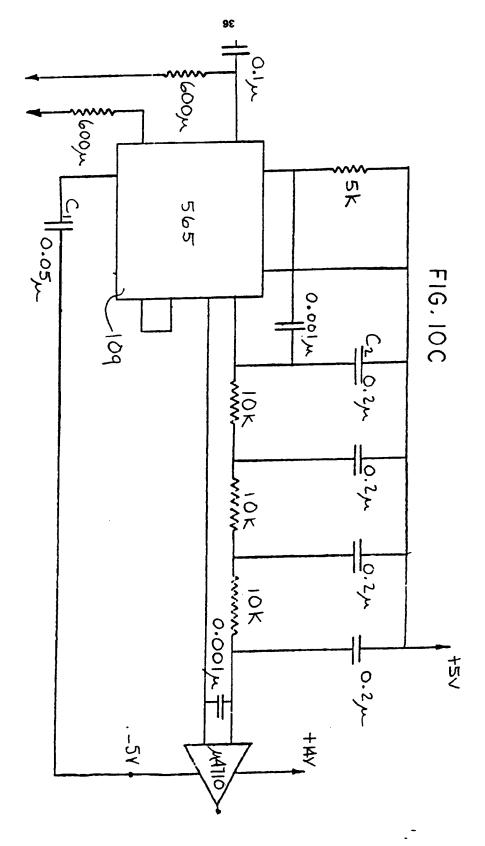




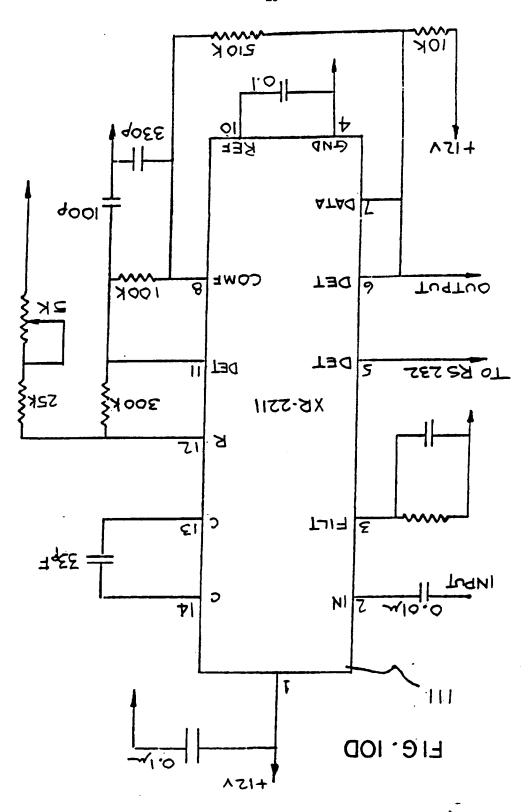




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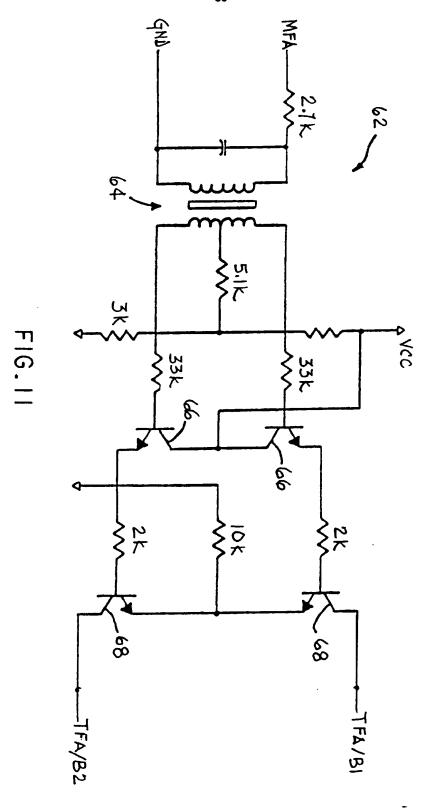


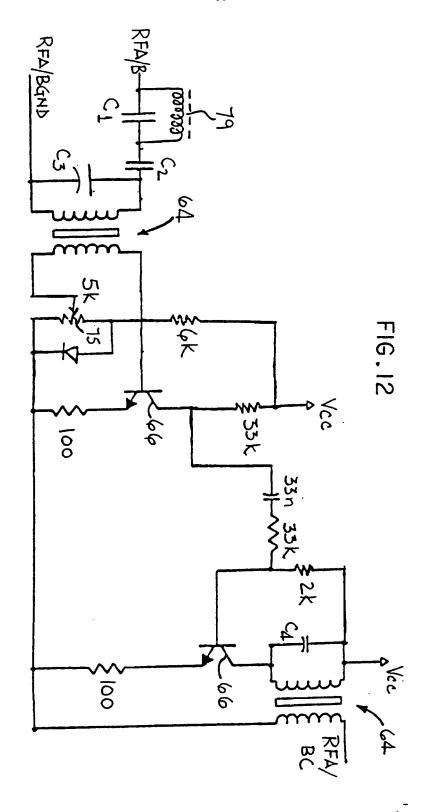
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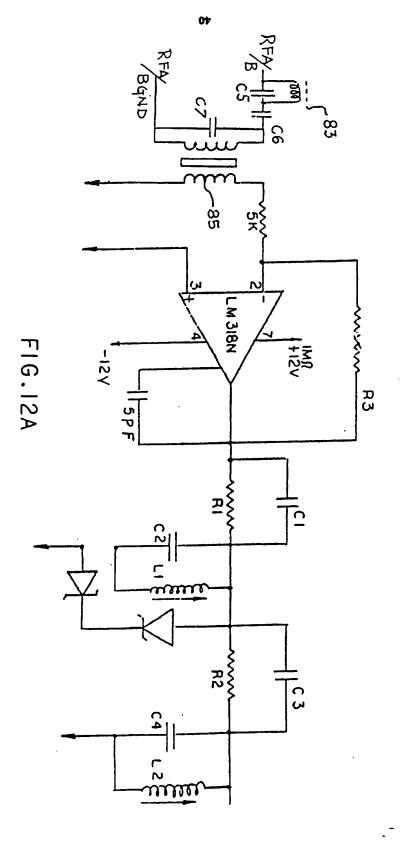
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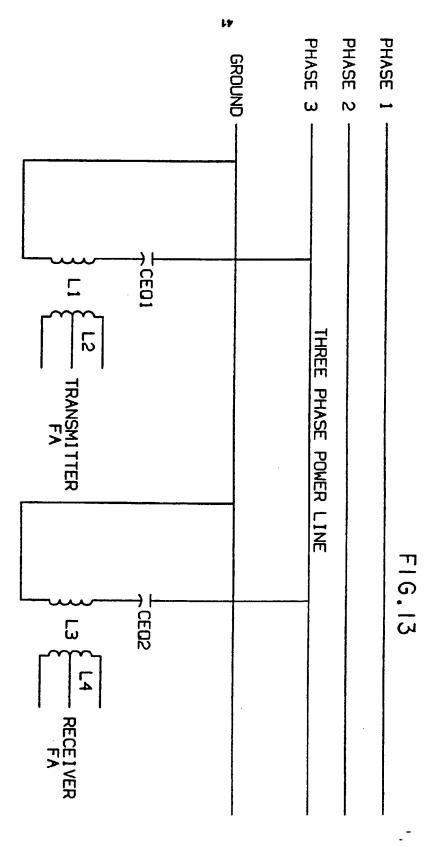




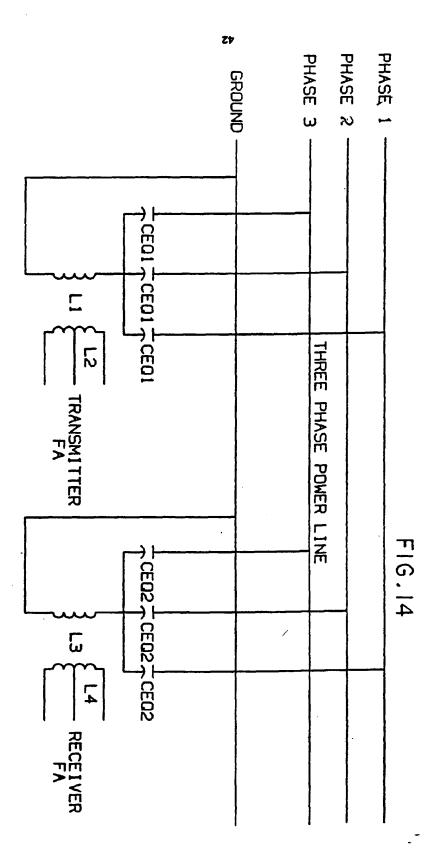
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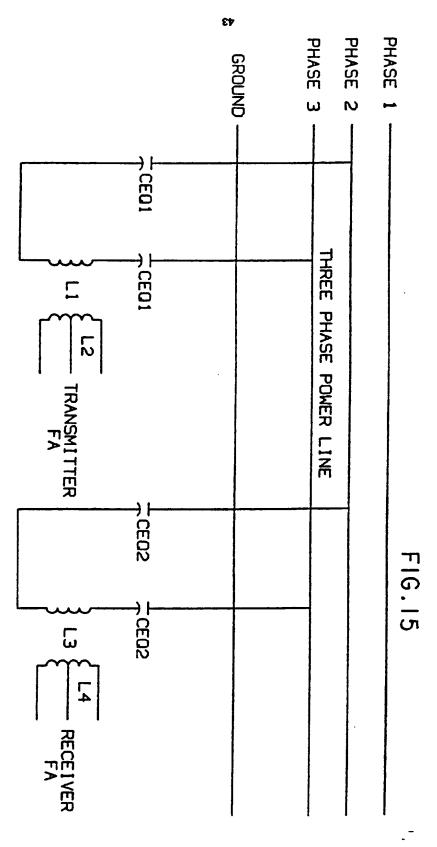
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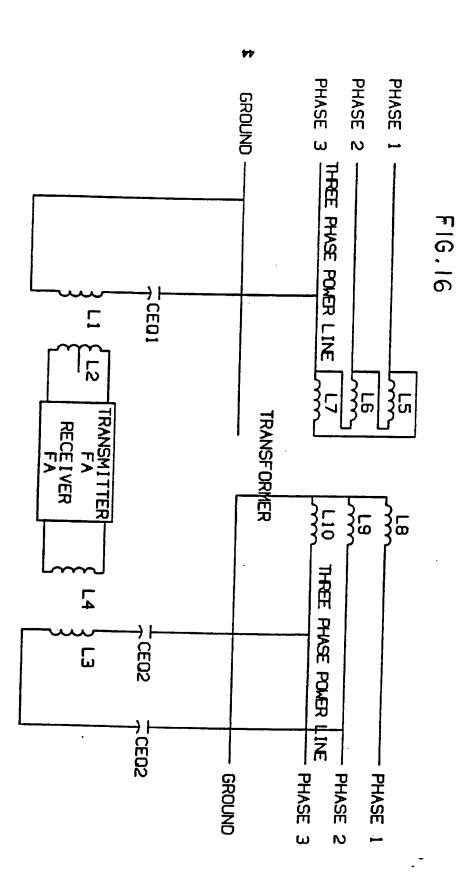
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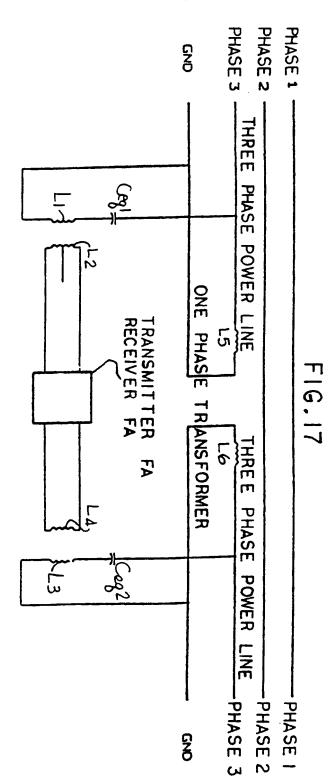
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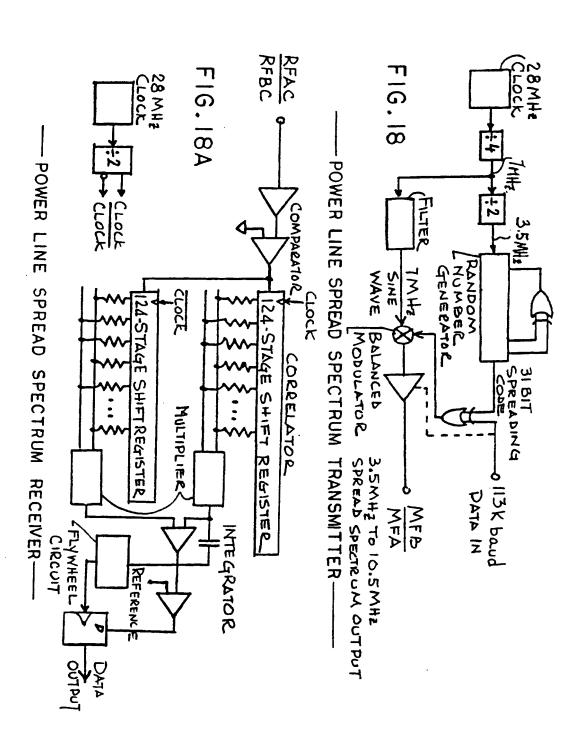


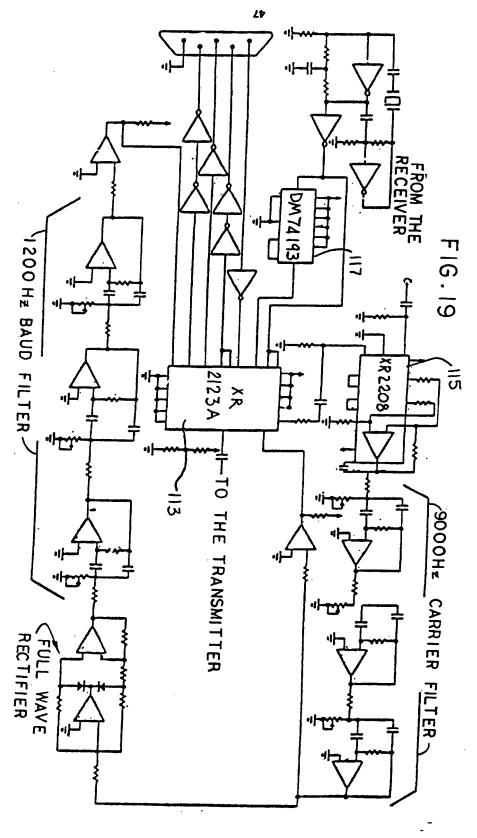
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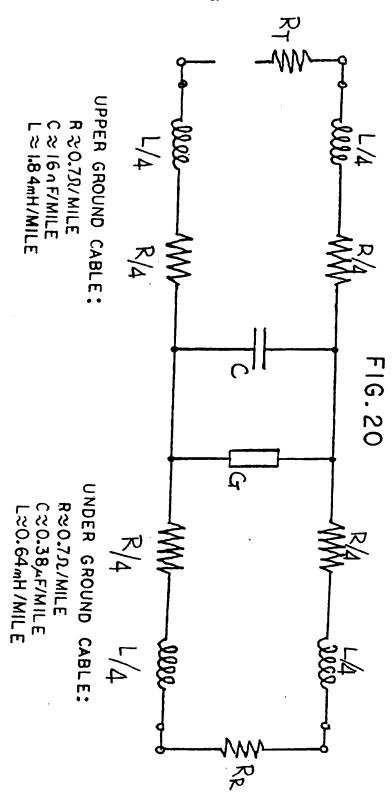
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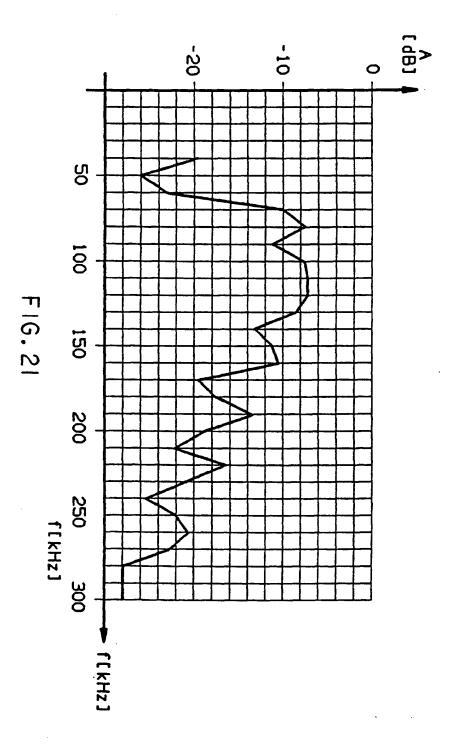


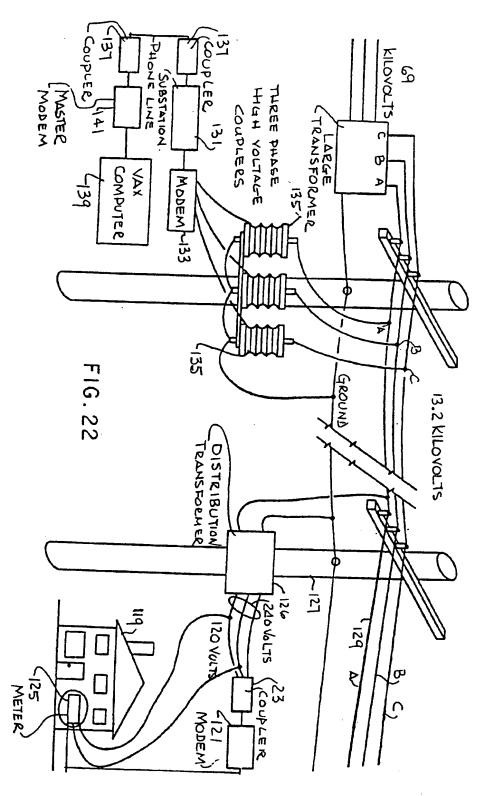
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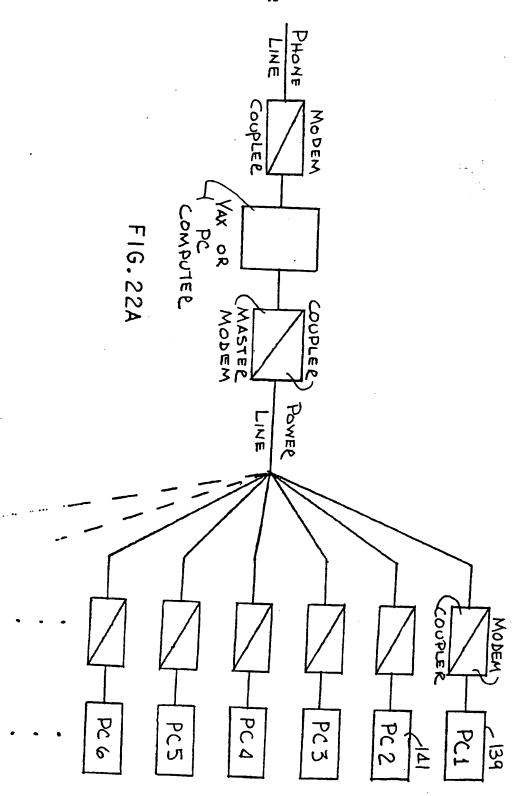


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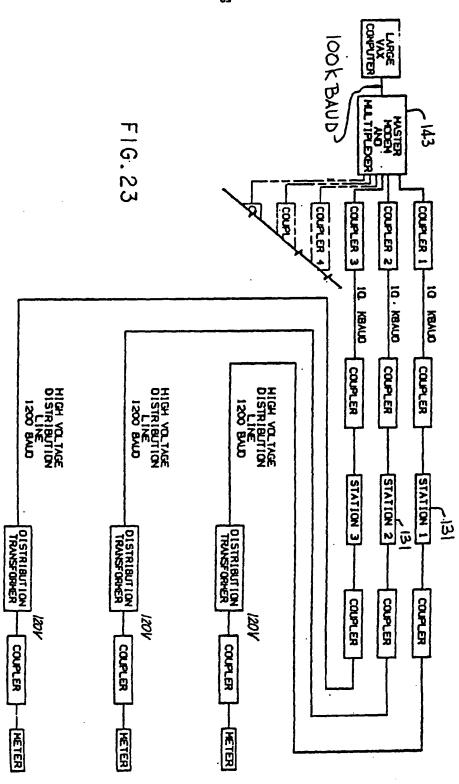




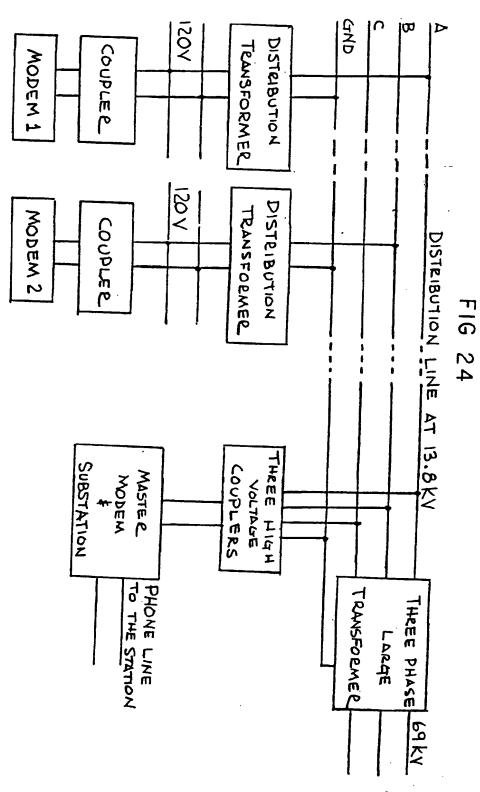




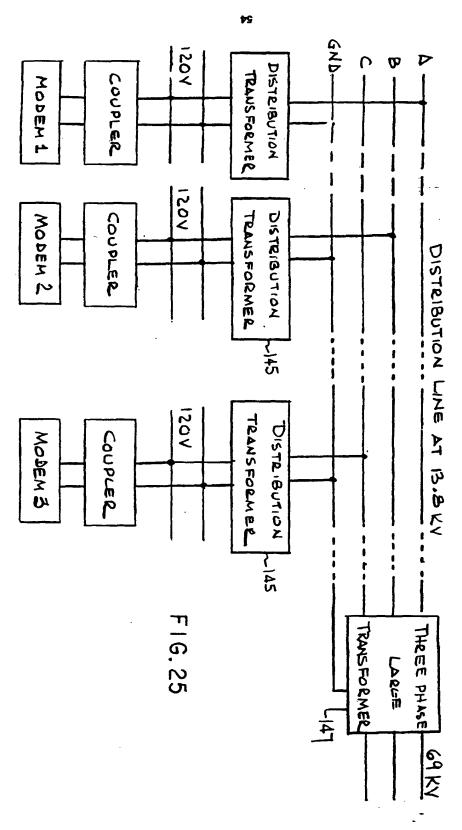
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